8806026

OFFICE COPY
DO NOT REMOVE

Rio Blanco Oil Shale Company

Tract C-a

Colorado Mined Land Reclamation

Regular Mining Permit Amendment

LURGI DEMONSTRATION PROJECT

December 1980

Gulf Oil Corporation/Standard Oil Company (Indiana)
'A General Partnership'
2851 South Parker Road, Aurora, Colorado 80014

81-0038

8802|369

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

TN
859
C64
R5653
1980
V.2

RIO BLANCO OIL SHALE PROJECT

MODULAR DEVELOPMENT PHASE

REGULAR RECLAMATION PERMIT APPLICATION

(VOLUME I)

SEPTEMBER 1977

Submitted to

COLORADO MINED LAND RECLAMATION BOARD

c/o MS. MAGGIE KOPERSKI

RECLAMATION SPECIALIST

by

RIO BLANCO OIL SHALE PROJECT

Gulf Oil Corporation
and
Standard Oil Company (Indiana)

RIO BLANCO OIL SHALE PROJECT

DAYTON COMMONS 9725 E. HAMPDEN AVENUE
DENVER, COLORADO 80231 303-751-2030

GULF OIL CORPORATION • STANDARD OIL COMPANY (INDIANA)

October 6, 1977

Colorado Mined Land Reclamation Board
Attention & c/o: Ms. Margaret A. Koperski
1313 Sherman Street
Denver, Colorado 80203

Letter of Transmittal

Dear Ms. Koperski:

The RBOSP Regular Reclamation Permit Application (Form 112) is attached to this letter of transmittal. Data, maps, reports, and other information supporting the application are enclosed.

The application fee was calculated to be $1606 (see attached sheet). Accordingly, a RBOSP bank draft for $1606 is attached.

RBOSP already has an Exploration Operations Bond to cover work on Tract C-a. Beginning on page 22 of the Tract C-a Lease (see Attachment A-1), the Federal Government stipulates that after approval of the Detailed Development Plan a bond in the amount of $2,000.00 per acre is required for sites of actual mining operations and $500 per acre for all other portions of the Leased Lands upon which operations will be conducted. The land on Tract C-a, which will be performance bonded for reclamation with the Federal Government is the same land to be bonded by the Colorado Mined Land Reclamation Board. RBOSP respectfully requests that the Board consider this apparent case of duplicate bonding for the performance of the same reclamation project contract and act according to their best judgment relative to this matter. The Rehabilitation and Reclamation guidelines of the Tract C-a Lease are also found in Attachment A-1 of this 112 application.

Finally, please be advised that Standard and Gulf received approval of the Tract C-a Revised Detailed Development Plan on September 22, 1977, and that since then we have been operating on Tract C-a under the Notice of Intent to Conduct Prospecting Operations which RBOSP filed with the Board on June 28, 1977 (along with evidence of a Statewide Prospecting Bond for $25,000.00).

Please contact Mr. Paul Marshall (RBOSP) if you have any questions regarding this Regular Reclamation Permit Application in order that the permitting process might be expedited.

Thank you for cooperation in the past and for your efforts on behalf of the Rio Blanco Oil Shale Project.

Very truly yours,

GULF OIL CORPORATION

By _____
L. V. Lombardi, Attorney-in-Fact

APPROVED AS TO FORM
10-5-77
LAW DEPT.

STANDARD OIL COMPANY (INDIANA)

By _____
R. M. Lieber, Attorney-in-Fact

:csa

cc: Mr. Pete Rutledge, Area Oil Shale Supervisor

RIO BLANCO OIL SHALE PROJECT
DAYTON COMMONS 9725 E. HAMPDEN AVENUE
DENVER, COLORADO 80231 303-751-2030

GULF OIL CORPORATION • STANDARD OIL COMPANY (INDIANA)

October 6, 1977

Colorado Mined Land Reclamation Board
Attention & c/o: Ms. Margaret A. Koperski
1313 Sherman Street
Denver, Colorado 80203

Post Script
Letter of Transmittal

Dear Ms. Koperski:

RBOSP has elected to permit the entire Federal Oil Shale Tract C-a and also a portion of T1S, R99W, Section 35 where the Corral Gulch Reservoir and Corral Gulch Reservoir Pipeline Corridor are planned (see Figure B-1). The Mined Land Reclamation Board Permit Area is outlined on Figure B-1 to include the Corral Gulch water system facilities. The total area of Tract C-a is 5089.70 acres (see attachment A-1 for legal description - page 8); the acreage required for the Corral Gulch water system is approximately 45 acres. Consequently, the total area to be considered for the MLRB permit is approximately 5135 acres. Negotiations have been initiated with the Carter Oil Co. and the Colorado Division of Wildlife to acquire the acreage for the Corral Gulch Reservoir water system.

As a result of the above discussed RBOSP election, a bank draft for the maximum MLRB application fee of $2000 minus the already deposited RBOSP bank draft in the amount of $1606 equals an amount due the MLRB of $394 to equal the maximum application fee. Accordingly, a RBOSP bank draft for $394 is attached.

The actual Affected Lands as defined in the Mined Land Reclamation Act equals 206 acres as detailed in the RBOSP Regular Reclamation Permit Application.

Professionally,

Paul W. Marshall

Paul W. Marshall,
Senior Mining Engineer
:csa

cc: R. M. Lieber
L. V. Lombardi
P. A. Rutledge

COLORADO MINED LAND RECLAMATION
REGULAR RBOSP MDP PERMIT APPLICATION
FEE CALCULATION

Total = 206 acres to be disturbed during MDP = "Affected Lands"

Basic fee	$ 50
First 50 acres = (50) ($15/acre) =	$750
Second 50 acres = (50) ($10/acre)=	$500
Third 50 acres = (50) ($5/acre) =	$250
Final 56 acres = (11) ($1/acre =	$ 56
	$1606

9/14/77
PWM

Regular Reclamation Permit Application Form 112, Question 14

RIO BLANCO OIL SHALE PROJECT
GULF MINERAL RESOURCES CO.
A DIVISION OF GULF OIL CORPORATION
STANDARD OIL COMPANY (INDIANA)
DAYTON COMMONS - 9725 E. HAMPDEN AVE.
DENVER, COLORADO 80231

4658

23-7
1020

September 19 19 77

Pay to the order of State of Colorado $ 1,606.00

- - - - - - - - - -One Thousand Six Hundred Six and no/100- - - - - - - - - - - - - - - - - - Dollars

United Bank Center, 1740 Broadway, Denver, Colorado 80217
United Bank of Denver
National Association

For Colorado Mined Land Reclamation Permit

⑆1020⑆0007⑆ 916 84 5⑈

RIO BLANCO OIL SHALE PROJECT
GULF MINERAL RESOURCES CO.
A DIVISION OF GULF OIL CORPORATION
STANDARD OIL COMPANY (INDIANA)
DAYTON COMMONS - 9725 E. HAMPDEN AVE.
DENVER, COLORADO 80231

4721

23-7
1020

October 7 19 77

Pay to the order of Colorado Mined Land Reclamation Board $ 394.00

- - - - - - - -Three Hundred Ninety-Four and no/100- Dollars

United Bank Center, 1740 Broadway, Denver, Colorado 80217
United Bank of Denver
National Association

For Regular Permit Application - Supplemental Acreage

⑆1020⑆0007⑆ 916 84 5⑈

REGULAR (112) PERMIT APPLICATION FORM

STATE OF COLORADO
Mined Land Reclamation Board
Department of Natural Resources
1313 Sherman Street, Room 723
Denver, CO 80203

Application for Mining and Reclamation Permit, Pursuant to C.R.S. 1973, 34-32-101 et seq.

TYPE OR PRINT CLEARLY

1.	Name of operations (Pit, mine, or site name)	Rio Blanco Oil Shale Project
2.	Name of applicant/operator (Name to be used on permit)	Gulf Oil Corporation - Standard Oil Company (Indiana)
3.	Address and phone number of local offices	Rio Blanco Oil Shale Project, 9725 E. Hampden Ave., Denver, Colo. 80231 (303) 751-2030
4.	Address and phone number of general offices	Same
5.	Name and phone number of person staff members should contact	Paul W. Marshall (303) 751-2030 Ext. 48
6.	Parent Corporation, if any (Include name & address)	Not Applicable
7.	Owner(s) of record of affected land (surface area) (If more than 2, list in Exhibit P)	United States of America, the State of Colorado - Game, Fish and Parks Department, and Carter Oil Co.
8.	Owner(s) of substance to be mined (If more than 2, list in Exhibit P)	United States of America
9.	Source of legal right to enter (Indicate what type of proof is included in Exhibit O - lease, deed, notarized letter, etc.)	Oil Shale Lease - see Attachment A-1
10.	Type of mine & substance to be mined (Specify underground, strip, open pit, etc. and substance(s) to be mined)	Underground Oil Shale Mine
11.	General location & elevation (Miles & direction from nearest town & approximate site elevation)	Federal Oil Shale Tract C-a is 20 miles southeast of Rangely at an average elevation of about 7,000 feet above sea level.
12.	County	Rio Blanco County
13.	Acreage of affected lands (Total surface acreage to be included in permit)	5135 acres for RBOSP Modular Development Phase and for purposes of the Mined Land Reclamation Act
14.	Application fee (See Rule 2 to determine amount)	$1606 (see attached sheet)
15.	Present land use (i.e., agricultural, industrial, etc.)	Rangeland, Wildlife Habitat
16.	Surrounding land uses	Rangeland, Wildlife Habitat, limited areas of agriculture (hay fields), scattered ranches.
17.	Proposed future land use (Goal of reclamation)	Rangeland, Wildlife Habitat.
18.	Other mining permits & operations in Colorado (See Rule 2 for guidance)	Edna Mine - Pittsburgh & Midway Coal Co. Parent Co., - Gulf Oil Corporation
19.	The lands herein do not affect any of the lands described in Section 1.56(9), (Specify affirmation)	See attached letter from Mr. Miller and Mr. Lieber dated 8/31/77.

MAPS & EXHIBITS

With each of the five (5) copies of the application form, the applicant must submit a corresponding set of the maps and exhibits outlined in Rule 2, as follows:

1. Exhibit A - Legal description
2. Exhibit B - Index map
3. Exhibit C - Pre-mining & mining plan
4. Exhibit D - Mining plan
5. Exhibit E - Reclamation plan
6. Exhibit F - Reclamation plan map
7. Exhibit G - Water information
8. Exhibit H - Wildlife information
9. Exhibit I - Soils information
10. Exhibit J - Vegetation information
11. Exhibit K - Climate
12. Exhibit L - Reclamation Costs
13. Exhibit M - Local government approval
14. Exhibit N - Other permits or licenses
15. Exhibit O - Source of legal right to enter
16. Exhibit P - Owners of record of surface & subsurface rights.

NOTICE PROCEDURES

After the application has been filed with the Division, notice procedures outlined in Rule 2.2 must be followed.

ADDITIONAL INFORMATION

This space can be referenced for further information of any of the items on this form.

It is the position of Standard and Gulf that all of the activities described in this Regular Reclamation Permit Application to be implemented between the date the Tract C-a DDP was approved (September 22, 1977) and the completion of the shaft sinking project, are prospecting activities, for purposes of the definition in the Mined Land Reclamation Act and in the Board's Rules and Regulations, which do not require a permit. Consistent therewith, RBOSP filed with the Board on June 28, 1977, a Notice of Intent to Conduct Prospecting Operations. (This is stated without waiver to the confidentiality of the information in such Notice.) Although this is the RBOSP position, in the spirit of cooperation and openness RBOSP has disclosed all of the proposed Modular Development Plan activities in this Application, and has no objection to any inspection of such activities at any reasonable time by any member of the Board or Division; provided that, this disclosure, inspection permission and Application are made without any prejudice whatsoever to these prospecting activities as so defined in the RBOSP position consistent therewith.

To the best of my knowledge, all the information presented in this application is true and correct.

BY: L. V. Lombardi
L. V. Lombardi

TITLE: Attorney-in-Fact, Gulf Oil Corporation

BY: R. M. Lieber
R. M. Lieber

TITLE: Attorney-in-Fact, Standard Oil Co. (Indiana)

(Signature by individual legally authorized to bind the operator to this application.)

RIO BLANCO OIL SHALE PROJECT

DAYTON COMMONS 9725 E. HAMPDEN AVENUE
DENVER, COLORADO 80231 . 303-751-2030

GULF OIL CORPORATION • STANDARD OIL COMPANY (INDIANA)

October 6, 1977 Regular Reclamation Permit Application
Form 112, Question 19

Colorado Mined Land Reclamation Board
Attention and C/O
Ms. Margaret A. Koperski
Reclamation Specialist
Colorado Mined Land Reclamation
1313 Sherman Street
Denver, CO 80203

Dear Ms. Koperski:

As requested in the Regular (112) Reclamation Permit Application Form under question 19, the following affirmation is made: The Rio Blanco Oil Shale Project Modular Development Phase will not affect any of the lands described in Section 1.56 (9) as quoted from the Rules and Regulations:

1.56 A permit shall not be denied except for one or more of the following reasons:

(9) The mining operation is located upon lands:

(a) where mining operations are prohibited by law or regulation within the boundaries of units of the national park system, the national wildlife refuge system, the national system of trails, the national wilderness preservation system, the wild and scenic rivers system, or national recreation areas;

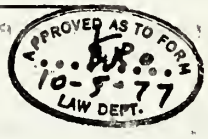
(b) which are within the boundaries of, and are owned, leased, or have been developed by, any recreational facility established pursuant to Article 7 of Title 29, C.R.S. 1973, unless otherwise authorized by the appropriate governing body or unless the operation will not create any surface disturbance therein;

(c) which are within the boundaries of, and are owned, leased, or have been developed by, any recreation district established pursuant to Article 2 of Title 32, C.R.S. 1973, unless otherwise authorized by the board of directors of the district or unless the operation will not create any surface disturbance therein; and

(d) which are within the boundaries of any unit of the state park system or any state recreational area in which the entire fee estate is owned by the state of Colorado, unless the mining operation is approved jointly by the board, by the governor, and by the board of parks and outdoor recreation, or unless the operation will not create any surface disturbance therein;

Signed

L. V. Lombardi
Attorney-in-fact
Gulf Oil Corporation



R. M. Lieber
Attorney-in-fact
Standard Oil Company (Indiana)

INTRODUCTION

Gulf Oil Corporation and Standard Oil Company of Indiana (the "Applicants" referred to collectively as "Gulf-Standard") hold as Lessees the Federal Oil Shale Lease (the "lease") awarded under the Prototype Oil Shale Leasing Program covering the tract known as "Tract C-a". Such tract covers the following described lands in Rio Blanco County, Colorado containing 5,089.70 acres, more or less.

Tract C-a is being operated under the name of Rio Blanco Oil Shale Project ("RBOSP") an organization directed and staffed by representatives of Gulf-Standard. RBOSP has studied and considered various mining and processing systems for the development of the oil shale resources on Tract C-a. In May, 1977 Gulf-Standard prepared a plan for the testing of the technical and economic feasibility of extraction of oil shale from the tract by means of the modified in situ ("MIS") method.

Under the MIS method of extraction, a small portion of the shale is removed in order to provide a void for the rubblization of a column of shale to be retorted in place. Whether the extraction of the oil shale values is accomplished by MIS methods or by other conventional mining methods, the dewatering of the area to be mined (or rubblized and retorted) is necessary. along with an associated water reinjection program.

This Regular Reclamation Permit Application has been prepared by the cooperative effort of technical and specialist employees of Applicants and by independent consultants employed by Applicants. The following table lists respectively, the names of the contributors to this report, the abbreviations utilized to identify such contributor and the sections of the report contributed by each:

Contributor	Identification Abbreviation	Exhibits Contributed
RBOSP (General)	RBOSP	A, B, C, D, G, M, N, O, and P
NUS Corporation through Mr. S. H. Miller (RBOSP)	NUS	E, F, G, H, I, J, K, and L
Morrison-Knudsen Co. through Mr. H. G. Kabbes (RBOSP)	M-K	C Partial
Hydrologic Consultants (Wright Water Engineers) (Scientific Software Corp.) (David E. Fleming Co.) through Mr. K. L. Berry (RBOSP)	(WWE, SSC, DEFCo)	G Partial

Certain portions of the Reclamation Permit Application were extracted and briefed from other reports heretofore prepared by RBOSP, limited copies of which have been submitted with the Application. Some of the Exhibits (chapters) contained in this report contain separate lists of sources of information utilized by the contributor in preparing the particular exhibit.

Applicant's Revised Detailed Development Plan (the "Revised DDP") submitted to the Area Oil Shale Supervisor in May, 1977 envisions development of Tract C-a in stages, first a Modular Development Phase ("MDP"), which if proven viable will be followed by another phase. The systems described herein are planned to cover only the Modular Development Phase from late 1977 through 1981. It has been assumed herein for planning purposes that the mining and development may cease at the end of 1981 except for such effort as may be necessary to return the groundwater and surface water regimes to the existing steady-state condition and such other abandonment and reclamation activities as may be appropriate. In other words, at the end of 1981, a decision will be made whether or not to proceed with another phase. If the decision is favorable, the reclamation plan defined by this Regular Reclamation Permit Application

will be amended to cover this other phase. If the decision is to surrender the Tract C-a Lease, final reclamation work will proceed as detailed in this 112 Application on the schedule included in the Reclamation Plan.

The Reclamation Plan is based on engineering studies made by Applicants and their consultants based on the best available technology. It is anticipated that final design studies now in progress as well as actual field conditions encountered may dictate changes in detail size and location of facilities; such as underground retorts, shafts, drifts, etc. Such changes would, of course, occasion concomittant changes in the detail location of dewatering wells or in other aspects of such systems. It is not anticipated, however that any such changes will substantively affect the overall reclamation plan. Technical revisions and/or amendments will be submitted to the Mined Land Reclamation Board if and as required by the Board.

The exhibit numbers, page numbers, figure numbers and attachment numbers in this application are keyed to the exhibits as listed on the back page of the 112 application form and also listed in the MLRB Rules and Regulations.

As specified in the MLRB Rules and Regulations, the following statement of affirmation is made:

> All tests, analyses, surveys and maps have been prepared by qualified persons. All the information submitted with the Regular Mined Land Reclamation Permit Application is accurate and complete relative to the design of the Modular Development Phase of the Rio Blanco Oil Shale Project as of September 1977 as attested to by:

Paul W. Marshall

Paul W. Marshall
State of Colorado
Registered Professional Engineer
Number 11310

VOLUME I

TABLE OF CONTENTS

MODULAR DEVELOPMENT PHASE
REGULAR RECLAMATION PERMIT APPLICATION

LETTER OF TRANSMITTAL & POST SCRIPT LETTER OF TRANSMITTAL

REGULAR PERMIT APPLICATION FORM

INTRODUCTION

EXHIBIT A

LEGAL DESCRIPTION A-1

EXHIBIT B

INDEX MAP B-1

EXHIBIT C

PRE-MINING AND MINING PLAN C-1

EXHIBIT D

MINING PLAN D-1

EXHIBIT E

RECLAMATION PLAN E-1

a. Description of Reclamation Objectives E-1

b. Compatibility of Proposed Postmining Land Use with Adjacent Land E-3

c. Implementation of the Reclamation Plan in Accordance with Rule 6 Reclamation Performance Standards E-3

d. Implementation of the Reclamation Plan in Accordance with Existing Environmental Conditions E-3

e. See Subsection 9 . . . . . E-4

f. Reclamation Plan E-4

(i) Schedule E-4

(ii) Size and Location of Affected Lands E-4

(iii) Sequence of Reclamation Phases E-4

g. Reclamation Plan E-4
(i) Segregation of Surface Soil E-4
(ii) Temporary Erosion Controls E-6
(iii) Grading E-7
(iv) Reapplication of Surface Soils E-7
(v) Seedbed Preparation E-8
(vi) Seeding E-8
(vii) Mulching E-9
(viii) Fertilizers E-10
(ix) Shrub Planting E-10
(x) Management E-10
LITERATURE CITED E-12

EXHIBIT F

RECLAMATION PLAN MAP F-1
a. Map of Affected Lands F-1
b. Proposed Final Land Use F-1

EXHIBIT G

WATER INFORMATION G-1
a. Statement of Effect G-1
b. Effects of Proposed Development on Surface and Groundwater Systems G-1
(i) Location of Water Resources in the Proposed Mining Area G-2
(ii) Aquifers in the Study Area G-2
(iii) Water Resource Management G-6
c. Water Requirements G-7
d. Water Sources and Water Rights G-7
e. Permit Application G-10
LITERATURE CITED G-11

EXHIBIT H

WILDLIFE INFORMATION H-1
a. Description H-1
(i) Mule Deer H-1
(ii) Elk H-4
(iii) Feral Horses H-5
(iv) Small and Medium Sized Mammals H-5
(v) Predatory Mammals H-8
(vi) Avifauna H-9
(vii) Reptiles and Amphibians H-14
(viii) Domestic Cattle H-15
b. Seasonal Use of the Area H-15
(i) Winter H-15
(ii) Spring H-16
(iii) Summer H-16
(iv) Fall H-16
c. Threatened and Endangered Species H-17
d. Anticipated Effects H-17
(i) Construction Impacts H-17
(ii) Mining Impacts H-19
(iii) Operational Impacts H-19
(iv) Storage and Transfer Impacts H-20
(v) Disposal Impacts H-20
(vi) Manpower Impacts H-21
(vii) Subsidence H-23
(viii) Environmental Actions H-23
(ix) Other Impacts H-24
LITERATURE CITED H-25
ATTACHMENT:H-1: Avifauna Species Identified from the Tract C-a Study Area During Two Years of Baseline Studies, October 1974 - September 1976 . . . . . H-26

ATTACHMENT H-2: Mammal Species Identified from the Tract C-a Study Area During Two Years of Baseline Studies, October 1974 - September 1976 . . . . . H-34

ATTACHMENT H-3: Species of Amphibians and Reptiles Encountered In the Vicinity of Tract C-a during two years of Baseline Studies, October 1974 - Sept. 1976. . . H-37

ATTACHMENT H-4: Wildlife Statement H-38

EXHIBIT I

SOILS INFORMATION I-1

a. Soil types and Distribution I-1

b. Chemical and Physical Characteristics of Soils in Study Area I-4

c. Suitability of Topsoil as a Plant Growth Medium I-4

LITERATURE CITED I-11

ATTACHMENT I-1: Soil Series Description for the Five Major Soil Types I-12

EXHIBIT J

VEGETATION INFORMATION J-1

a. Description of Existing Vegetation J-1

(i) Aspen J-1

(ii) Douglas-fir J-13

(iii) Mixed Brush J-14

(iv) Pinyon-juniper J-15

(v) Sagebrush J-16

(vi) Bold J-20

(vii) Shadscale J-20

(viii) Riparian J-21

b. Relationship of the Dominant Vegetation Types Existing on Tract C-a to Soil Types J-22

c. Productivity of the Vegetation Types on Tract C-a . . . J-23

LITERATURE CITED. J-26

ATTACHMENT J-1: Species of Plants Observed in the Vicinty of Tract C-a During 1974-1976 . . . . . J-27

ATTACHMENT J-2: Species of Plants Observed in the Vicinity of Tract C-a During 1976 . . . . . J-50

EXHIBIT K

CLIMATE K-1

EXHIBIT L

RECLAMATION COSTS L-1

EXHIBIT M

LOCAL GOVERNMENT APPROVAL M-1

EXHIBIT N

OTHER PERMITS OR LICENSES N-1

REGULATORY REQUIREMENT N-2

I. Federal N-2

II. State N-3

III. Local N-6

EXHIBIT O

SOURCE OF LEGAL RIGHT TO ENTER O-1

EXHIBIT P

OWNERS OF RECORD OF AFFECTED LAND AND OWNERS OF SUBSTANCE TO BE MINED P-1

LIST OF FIGURES

Figure Number		Page
	EXHIBIT B	
B-1	Location of Tract C-a	See Volume II
B-2	Aerial Photo - RBOSP Tract C-a	B-2
	EXHIBIT C	
C-1	Surface Ownership	See Volume II
C-2	MDP Mining, Porcessing Facilities and Surface Ownership	See Volume II
C-3	Tract C-a - Area Disturbed by Year	See Volume II
C-4	Present Vegetation	See Volume II
C-5	Soil Types	See Volume II
C-6	Top Soil Depth in Centimeters	See Volume II
	EXHIBIT D	
D-1	MDP Mine Layout Sketch Preliminary	See Volume II
D-2	Water Importation System Corral Gulch Reservoir	D-3
	EXHIBIT F	
F-1	Tract C-a - Area Reclaimed by Year	See Volume II
	EXHIBIT G	
G-1	Locations of Surface Streams in Study Area	G-3
G-2	Piceance Creek Hydrologic Basin	G-4
G-3	Upper and Lower Bedrock Aquifers under Tract C-a	G-5
	EXHIBIT I	
I-1	Soils Map of Tract C-a and Vicinity	I-2
I-2	Depth of Top Soils for Tract C-a and Vicinity	I-7

EXHIBIT J

J-1 Location and Extent of Vegetation Types on Tract C-a and Vicintiy . . . . . See Volume II

J-2 Cover and Number of Herbaceous Species Sampled on Permanent Transects in Vegetation Types and Associations Identified fro RBOSP (1975-1976) . . J-8

EXHIBIT M

M-1 Resolution M-2

LIST OF TABLES

Table Number		Page
	EXHIBIT D	
D-1	Affected Lands Disturbance Classification	D-4
	EXHIBIT E	
E-1	Estimated Acreages of Land Scheduled to be Disturbed and Revegetated on Tract C-a	E-2
E-2	Schedule of Reclamation Activities by Year for Each of the Affected Lands	E-5
	EXHIBIT H	
H-1	Mule Deer Observed on Four Census Areas During Eleven Survey Periods, Winter, 1974-1975 for RBOSP	H-3
H-2	Mule Deer Observed During Sixteen Survey Flights, June 1975 to September 1976 for RBOSP	H-3
H-3	Number of Feral Horses Observed During Twenty Aerial Surveys During 1974-1975 for RBOSP	H-6
H-4	Small Mammal Trapping Summary for All Grids During Each Sampling Period for RBOSP	H-7
H-5	Total Avian Densities (Individual Per Hectare) in Fifteen Habitat Types Sampled During 1974-1976 for RBOSP	H-10
H-6	Raptor Species Noted on RBOSP Tract C-a Study Area During 1974-1976	H-13
	EXHIBIT I	
I-1	Chemical and Physical Traits of Soils of the Study Area	I-5
I-2	Chemical and Physical Traits of the Major Soil Series	I-6
	EXHIBIT J	
J-1	General Information Regarding Vegetation Types and Associations Sampled in the Tract C-a Vicintiy During 1974-1976 for RBOSP	J-2

J-2 Quantitative Data for Tree and Shrub Species Ocurring in Vegetation Types and Associations Identified for RBOSP, 1975-1976 . . . . . J-4

J-3 Cover and Frequency of Dominant Herbaceous Species Sampled on Permanent Transects in Vegetation Types and Associations for RBOSP, 1975-1976 . . . . . J-9

J-4 Relationship of the Soil Types to the Dominant Vegetation on Tract C-a J-22

J-5 Forage Production and Utilization Estimates Obtained in the Fall of 1975 on and near Tract C-a J-25

EXHIBIT K

K-1 Precipitation (inches) Recorded at Four Locations Near Tract C-a, 1975 and 1976 . . . . . K-2

K-2 Comparison of Temperature, Precipitation, and Evaporation Data in the Tract C-a Vicinity (50 Mile Radius) for 1975, RBOSP K-4

K-3 Seasonal Ambient Temperature Ranges (^{o}C) for Tract C-a (Site 4) 1975 and 1976 . . . . . K-5

K-4 Summary of Annual Climatological Parameters for Tract C-a, Rio Blanco County, Colorado. K-6

EXHIBIT
A

EXHIBIT A

LEGAL DESCRIPTION

EXHIBIT A - LEGAL DESCRIPTION

The legal description of RBOSP Tract C-a is contained in Attachment A-1 entitled: Tract C-a, Oil Shale Lease Environmental Stipulations and References on page 8 under the definition of "Leased Lands." The Corral Gulch Reservoir is just off Tract C-a as shown on Figures B-1* and Figure D-2 (Volume I) and is located in portions of T1S, R99W, Section 35 (see Post Script Letter of Transmittal).

* Volume II

EXHIBIT
B

EXHIBIT B

INDEX MAP

EXHIBIT B - INDEX MAP

Figure B-1* indicates the location of the town of Rangely, Colorado relative to the location of the RBOSP Tract C-a which is also outlined. A 5-mile perimeter around Tract C-a is shown to delineate the Environmental study area that was thoroughly investigated by the NUS Corporation. NUS authored major sections of this regular reclamation permit application and are currently acting in a consultant capacity to RBOSP.

Figure B-2 is an aerial photo of the RBOSP Tract C-a area.

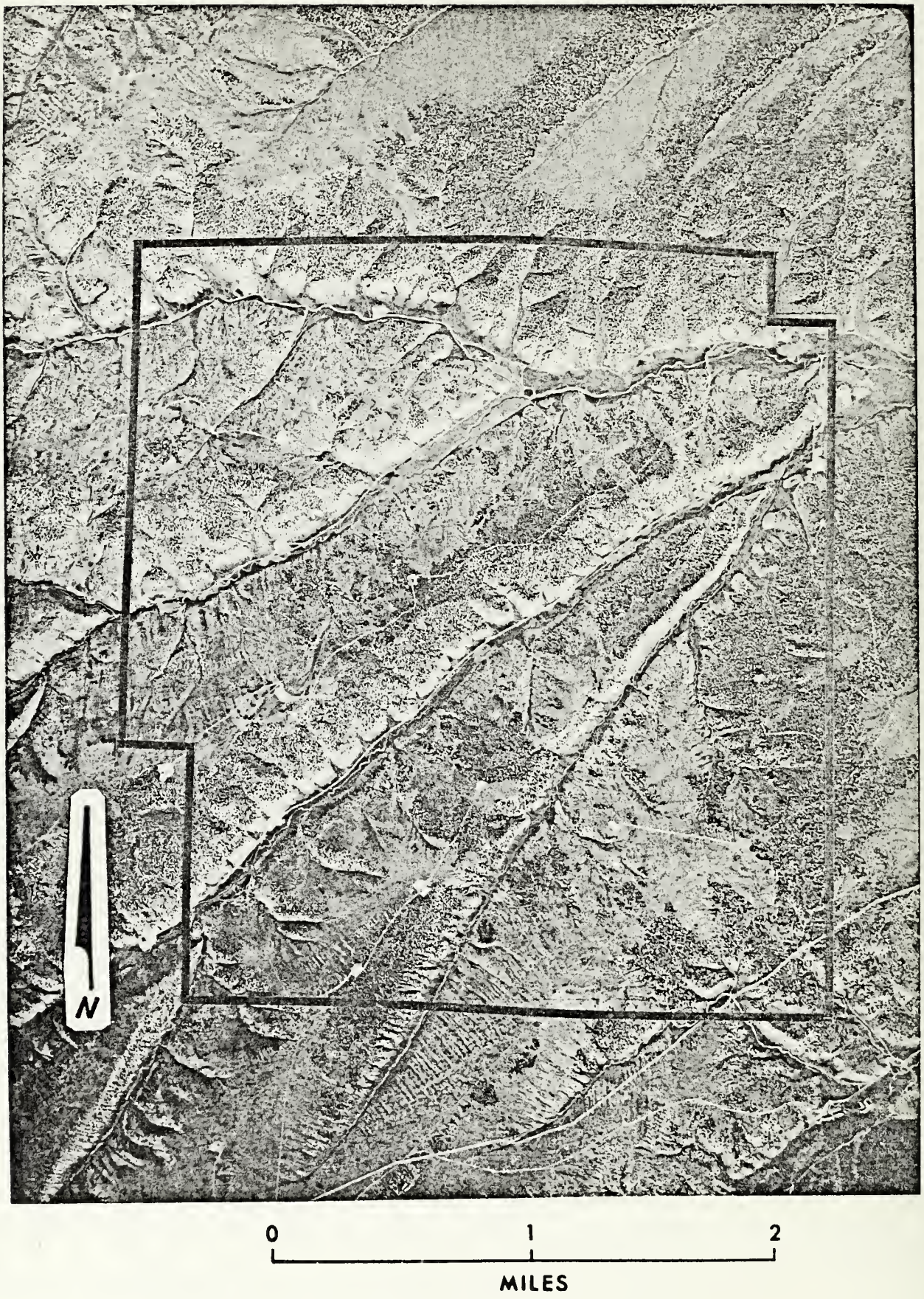


Figure B-2
AERIAL PHOTO - RBOSP TRACT C-a
B-2

EXHIBIT
C

EXHIBIT C

PRE-MINING & MINING PLAN

EXHIBIT C - PRE-MINING AND MINING PLAN

a. The immediately adjacent surface owners of record are shown on Figure C-1*.

b. The names and locations of all creeks, roads and buildings are shown on Figure C-2*. There are no oil wells or gas wells on Tract C-a. A buried natural gas pipeline crosses the Southeast corner of Tract C-a. The 14-inch diameter main gas transmission line is a 25-foot right-of-way in the SE¼ SE¼ of Section 10 and is owned by the Cascade Natural Gas Corporation. Powerlines are also shown on Figure C-2* (See Legend for symbols). There are no communication lines in the tract area as a microwave phone system was installed in the RBOSP Tract visitors center.

c. Topography of the tract and vicinity is shown on Figure B-1* (Index Map) and also Figure C-2*.

d. The total area involved in the RBOSP MDP operation is shown on Figure C-3* which was supplied by the Morrison-Knudsen Company currently acting as general design contractor for the project. The 5 retorts to be mined during the MDP are shown on Figure C-2* as well as MDP Mining and Processing Facilities outline. Pipelines, roads and a transmission line are also illustrated as part of "affected lands" and details of the MDP Mining and Processing Facilities are represented on Figure C-3*.

e. The type of present vegetation is shown in Figure C-4*. Vegetation is further discussed in Exhibit J of this permit application. Figure C-5* shows the Top Soil Types on Tract C-a and Figure C-6* illustrates the associated Top Soil Depths in centimeters.

* See Volume II

EXHIBIT D

MINING PLAN

EXHIBIT D - MINING PLAN

a. The MDP of the RBOSP is described in detail in theRevised Detailed Development Plan (RDDP) in Volume 2, Chapter 6 entitled "Mine Design" (see Attachment D-1). More detailed design work continues both in house and by the design contractor Morrison-Knudsen Co. (M-K). The 15 ft. finished diameter shaft will be sunk to a depth of about 900 ft. Conventional shaft sinking methods will probably be employed by a shaft sinking contractor. A second, 7 ft. finished diameter shaft will be constructed as well as an ore pass system to serve the MDP mining activity. The completion of the above described shafts sinking project will mark the end of RBOSP Prospecting Activity as defined by the Colorado Mined Land Reclamation Act. The MDP mine will be developed off the two mentioned shafts on an approximate schedule shown on Figure D-1 which illustrates the layout of the 5 MDP retorts. These 5 retorts will be outlined, rubblized, and burned within the budgetary constraints of $93 million. All 5 retorts may not be burned because of budgetary limitations. On the other hand, a 6th retort or an alternate design retort may be constructed. However, any such change in MDP plans will be submitted to the Mined Land Reclamation Board as required by the MLRB Rules and Regulations.

A request for a variance to State and Federal Mining Regulations has been submitted for the RBOSP MDP. The request petitions for a variance to use petroleum products in an underground mine for ignition of the MDP retorts. In addition, the request indicates the need for a variance to permit a fire in an underground mine.

The MDP time table began on September 22, 1977, the date of our receipt of approval for the RBOSP RDDP from Mr. Peter A. Rutledge, the Area Oil Shale Supervisor, and it will end approximately January, 1982. The MDP of the project is now more distinct from subsequent phases that were described in the DDP. Following the MDP, a decision will be made in early 1982 as to a subsequent phase. If the decision is to proceed to a

EXHIBIT D - MINING PLAN

a. The MDP of the RBOSP is described in detail in theRevised Detailed Development Plan (RDDP) in Volume 2, Chapter 6 entitled "Mine Design" (see Attachment D-1). More detailed design work continues both in house and by the design contractor Morrison-Knudsen Co. (M-K). The 15 ft. finished diameter shaft will be sunk to a depth of about 900 ft. Conventional shaft sinking methods will probably be employed by a shaft sinking contractor. A second, 7 ft. finished diameter shaft will be constructed as well as an ore pass system to serve the MDP mining activity. The completion of the above described shafts sinking project will mark the end of RBOSP Prospecting Activity as defined by the Colorado Mined Land Reclamation Act. The MDP mine will be developed off the two mentioned shafts on an approximate schedule shown on Figure D-1 which illustrates the layout of the 5 MDP retorts. These 5 retorts will be outlined, rubblized, and burned within the budgetary constraints of $93 million. All 5 retorts may not be burned because of budgetary limitations. On the other hand, a 6th retort or an alternate design retort may be constructed. However, any such change in MDP plans will be submitted to the Mined Land Reclamation Board as required by the MLRB Rules and Regulations.

A request for a variance to State and Federal Mining Regulations has been submitted for the RBOSP MDP. The request petitions for a variance to use petroleum products in an underground mine for ignition of the MDP retorts. In addition, the request indicates the need for a variance to permit a fire in an underground mine.

The MDP time table began on September 22, 1977, the date of our receipt of approval for the RBOSP RDDP from Mr. Peter A. Rutledge, the Area Oil Shale Supervisor, and it will end approximately January, 1982. The MDP of the project is now more distinct from subsequent phases that were described in the DDP. Following the MDP, a decision will be made in early 1982 as to a subsequent phase. If the decision is to proceed to a

EXHIBIT D - MINING PLAN

a. The MDP of the RBOSP is described in detail in theRevised Detailed Development Plan (RDDP) in Volume 2, Chapter 6 entitled "Mine Design" (see Attachment D-1). More detailed design work continues both in house and by the design contractor Morrison-Knudsen Co. (M-K). The 15 ft. finished diameter shaft will be sunk to a depth of about 900 ft. Conventional shaft sinking methods will probably be employed by a shaft sinking contractor. A second, 7 ft. finished diameter shaft will be constructed as well as an ore pass system to serve the MDP mining activity. The completion of the above described shafts sinking project will mark the end of RBOSP Prospecting Activity as defined by the Colorado Mined Land Reclamation Act. The MDP mine will be developed off the two mentioned shafts on an approximate schedule shown on Figure D-1 which illustrates the layout of the 5 MDP retorts. These 5 retorts will be outlined, rubblized, and burned within the budgetary constraints of $93 million. All 5 retorts may not be burned because of budgetary limitations. On the other hand, a 6th retort or an alternate design retort may be constructed. However, any such change in MDP plans will be submitted to the Mined Land Reclamation Board as required by the MLRB Rules and Regulations.

A request for a variance to State and Federal Mining Regulations has been submitted for the RBOSP MDP. The request petitions for a variance to use petroleum products in an underground mine for ignition of the MDP retorts. In addition, the request indicates the need for a variance to permit a fire in an underground mine.

The MDP time table began on September 22, 1977, the date of our receipt of approval for the RBOSP RDDP from Mr. Peter A. Rutledge, the Area Oil Shale Supervisor, and it will end approximately January, 1982. The MDP of the project is now more distinct from subsequent phases that were described in the DDP. Following the MDP, a decision will be made in early 1982 as to a subsequent phase. If the decision is to proceed to a

subsequent phase, the final or ultimate reclamation may be delayed, as indicated on Figure F-1, pending the Board's approval of that phase.

b. "Earthmoving" for the MDP will be accomplished according to the design and schedule employed in Figure C-3*.

c. "All water diversion and impoundment" are shown on Figure C-3*. In addition, the Corral Gulch Reservoir, which is just off the northeast corner of Tract C-a, is illustrated in Figure B-1* and in more detail in Figure D-2*. The centerline of Corral Gulch Reservoir and its location relative to the MDP Mining and Processing Facilities are shown in Figure D-2; the method of construction of the Corral Gulch Reservoir is indicated in the righthand side of the same Figure D-2. The detail design work on the MDP water diversion system and the MDP runoff containment system are not available. Suffice it to state, however, as detailed in the RDDP in Volume III, Section 6 Chapter 6, a 100-year storm criteria will be employed by M-K for detailed design work. Figure C-3* represents initial design work relative to both the water diversion and runoff control systems where the objectives are a zero discharge operation.

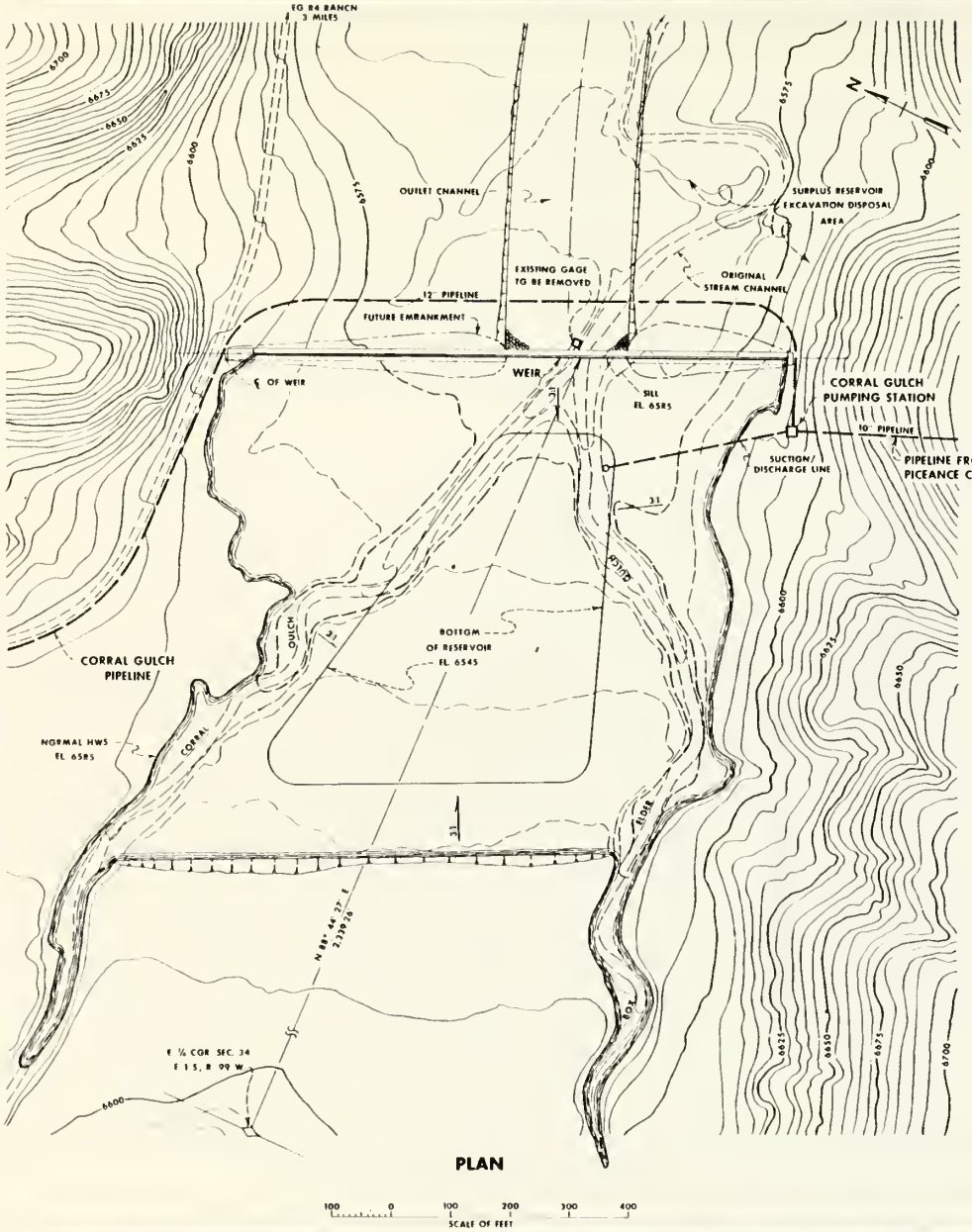
d. The acreages to be disturbed each year during the MDP are given in Table E-1 and are illustrated in Figure C-3*. The detailed disturbances depicted in Figure C-3* can be classified as shown in Table D-1 page D-4.

e. Timetable to describe the mining operation.

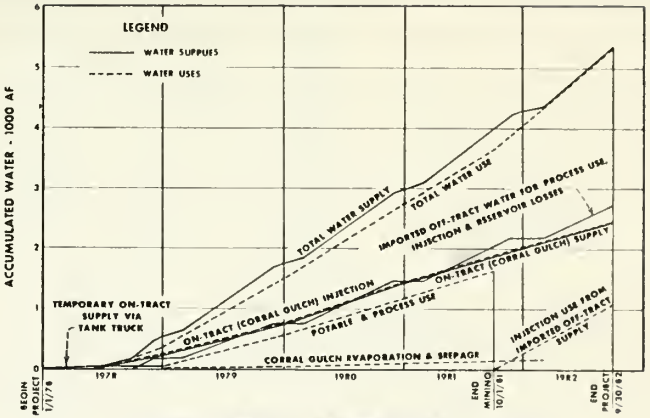
i) The RBOSP Modular Development Phase is scheduled on Figure D-1* and the order of accuracy of the schedule is about plus or minus 4 months.

ii) A description of the size and location, by survey coordinates, is shown on Figure D-1* and also Figure C-2*. Retort #1 will be 30 ft. by 30 ft. by 140 ft. high. Retorts #3 and 3A will be 50 ft. by 100 ft. by 140 ft. high. Retorts 5 and 5A will be 100 ft. by 100 ft. by 400 ft. high.

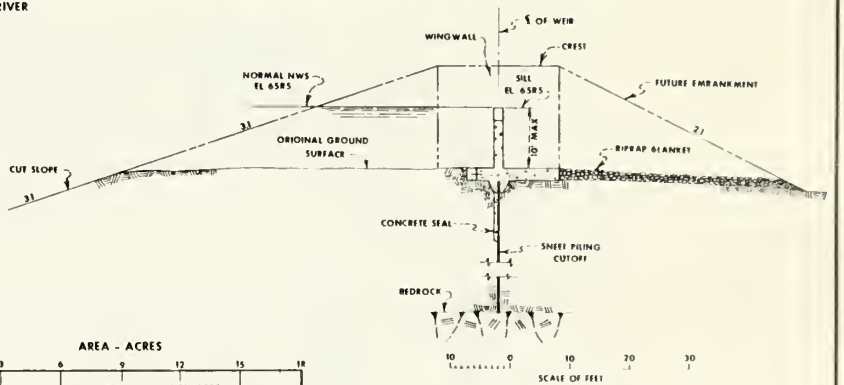
*See Volume II



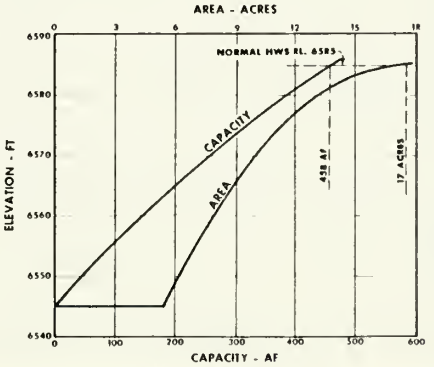
PLAN



ON-TRACT SURFACE WATER USES AND SUPPLIES



SECTION THROUGH WEIR



AREA - CAPACITY CURVES

RIO BLANCO OIL SHALE PROJECT

WATER IMPORTATION SYSTEM

FIGURE D-2

CORRAL GULCH

RESERVOIR

THE DAVID E. FLEMING COMPANY/ CONSULTING ENGINEERS
DENVER, COLORADO AUGUST 1977

TABLE D-1

AFFECTED LANDS DISTURBANCE CLASSIFICATION

Disturbance Type	Classification	Year			
		1977	1978	1979	
Access	Moderate	10			
Plant Site Area	Major	15	30		
Ponds	Moderate	25			
ROM Ore & Soil Storage	Major		6	24	
Service Road	Moderate	12			
Injection System	Moderate	24	5		
Transmission Line	Moderate		15		
Corral Gulch Reservoir	Major		40		
					TOTAL
	Total Major	15	81	24	120
	Total Moderate	71	15	0	86

Total Disturbed Acres = 206

Note: This Table correlates with Table E-1

iii) The outline of the sequence in which each stage of the operation has been carried out has been described in the RDDP (Attachment D-1), Volume II, Section 2, Chapter 6, Mine Design and also in Exhibit D, Part a.

iv) The nature, depth, and thickness of the oil shale and overburden are discussed in the RDDP (Attachment D-1), Volume II, Section 2, Chapter 3 entitled: "Geology"; the nature of the strata beneath each retort is indicated in the same chapter.

*See Volume II

EXHIBIT
E

EXHIBIT E

RECLAMATION PLAN

EXHIBIT E - RECLAMATION PLAN

a. Description of Reclamation Objectives

During 1977-1981, Rio Blanco Oil Shale Project (RBOSP) will engage in the Modular Development Phase (MDP) of their oil shale activities on Tract C-a in Rio Blanco County, Colorado. Limited land disturbance will occur in the immediate Tract C-a vicinity as a result of MDP mining activities (Table E-1). RBOSP will restore affected lands to a self-sustaining condition similar to presently existing land uses in the area and one that is compatible with adjacent undisturbed areas. Future land uses of reclaimed areas include rangeland and wildlife habitat except for the MDP mining and processing facilities area which will remain industrial unless RBOSP ceases mining activities in 1981. If the Tract C-a Lease is surrendered by RBOSP, then the mine area (plant site, service pond, and ore disposal area) will be reclaimed to support range and wildlife use. The surface rehabilitation plan described herein details the RBOSP revegetation program which has been designed to successfully fulfill all lease requirements (Attachment A-1) and to meet the reclamation performance standards of the Colorado Mined Land Reclamation Board. This reclamation plan is based on the current results of the RBOSP experimental revegetation program (RBOSP 1977a; RBOSP 1977b, see page E-12). This program was initiated in the fall of 1975 with two test plots and a third plot was initiated in the fall of 1976. The current results indicate that disturbed areas on Tract C-a can be successfully revegetated with no or minimal irrigation, depending on specific climatic conditions of the first growing season. Studies of the three revegetatior plots will continue to determine successional changes during the early years of establishment and growth.

Land disturbance will result from: construction of the plant site, roads, ponds, transmission corridors, Corral Gulch Reservoir, and the water injection system; disposal of the run-of-mine ore from the mine; and stockpiling of surface soil (Table E-1, Figure C-3*). Surface

* See Volume II

TABLE E-1

ESTIMATED ACREAGES OF LAND SCHEDULED TO BE DISTURBED AND REVEGETATED ON TRACT C-a

	YEAR	1977				1978				1979				
	QUARTER	1	2	3	4	1	2	3	4	1	2	3	4	
Access Road				10										
Plant Site Area				10	5	14	16							
Ponds				6	19									
ROM Ore & Soil Storage									6	6	6	6	6	
Service Road					12									
Injection System					24		5							
Transmission Line							15							
Corral Gulch Reservoir							20	20						
SUB-TOTAL				26	60	14	56	20	6	6	6	6	6	
TOTAL														206

RECLAIMED

		1978					1982				
		1	2	3	4		1	2	3	4	
Access Road					3						
Plant Site Area*										45	
Ponds*										25	
ROM Ore & Soil Storage*										30	
Service Road					4						
Injection System					29						
Transmission Line					15						
Corral Gulch Reservoir										Left Intact	
SUB-TOTAL					51					100	
TOTAL											151

*Will be reclaimed if the Tract C-a Lease is surrendered.

disturbances resulting from construction will be reclaimed by grading and revegetation techniques. Disposal areas will be covered with 6-12 inches of stockpiled surface soil, graded and revegetated.

b. Comparison of Proposed Postmining Land Uses to Other Land Uses in the Vicinity and to Adopted State and Local Land Use Plans and Programs.

The objective of the RBOSP revegetation plan is to restore affected lands to a self-sustaining rangeland/wildlife habitat similar to that presently existing in the vicinity of Tract C-a (Figures C-4* and J-1*). Rangeland on Tract C-a includes primarily the sagebrush vegetation types. Pinyon-juniper, sagebrush, and mixed brush provide important wildlife habitat (See Exhibit H). The proposed postmining land uses are compatible with the Piceance Wildlife Habitat Management Plan (1977).

c. Implementation of the Reclamation Plan in Accordance with Rule 6 - Reclamation Performance Standards.

See Subsections f and g.

d. Implementation of the Reclamation Plan--Rehabilitation of the Affected Land and Its Relationship to Conditions of Natural Vegetation, Wildlife, Water, Air and Soil.

The lands disturbed by MDP activities will be primarily sagebrush and pinyon-juniper vegetation types (Figure C-4*). The reclamation plan includes using plant species native to these two vegetation types which will provide forage and browse for the existing fauna.

During reclamation activities appropriate erosion control measures (e.g., mulching, grading, construction of water bars) will be implemented to conserve natural soil resources and to prevent siltation of Corral Gulch. Revegetation activities will be completed as soon as feasible to minimize fugitive dust problems.

Diversion ditches will be constructed above the mine site area to divert runoff from the mine area to Corral Gulch. Runoff ditches will be constructed around the mine area and disposal pile to collect water falling on these areas and therefore to prevent contamination of the Corral Gulch water.

e. See Subsection g.

f. Reclamation Schedule

(i) Schedule

A schedule by year of the various reclamation activities is presented in Table E-2. Since the construction of the roads, transmission corridor, and water injection system are expected to be completed in 1977, reclamation for these areas is scheduled for 1978 - 1979. Reclamation of the plant site, ponds, and disposal area is not anticipated during MDP unless the Tract C-a Lease is surrendered by RBOSP. At that time RBOSP would complete all reclamation activities. (See Exhibit D, Subsection a). The Corral Gulch Reservoir will be permanent since it will positively benefit domestic animal and wildlife, particularly waterfowl. Therefore, slopes will be no steeper than 2:1 except from 5 feet above to 10 feet below the water line where slopes will be no steeper than 3:1 in accordance with MLRB Rule 6 - Reclamation Standards. Additional information regarding seasonal reclamation activities is discussed in Subsection g.

(ii) Size and Location of Affected Lands

Acreage expected to be disturbed by mining activities is presented in Table E-1. Total disturbed land is not expected to exceed 206 acres of which approximately 50 acres will be revegetated by 1982. An additional 100 acres will be reclaimed in 1982 - 1983 if the Tract C-a Lease is surrendered. The location of these disturbed lands is presented in Figure C-3* and reclaimed areas are presented in Figure F-1*.

* See Volume II

TABLE E-2

SCHEDULE OF RECLAMATION ACTIVITIES BY YEAR FOR EACH OF THE AFFECTED LANDS

Reclamation Activities	Affected Lands						
	Plant Site[2]	Run-of-Mine Disposal[2]	Soil Storage	Road Berms	Water Injection System	Pond[2]	Transmission Corridor
Segregation of Surface Soil	1977	1978				1977	
Temporary Erosion Control			1978				
Grading	1982	1982	1982	1978	1978	1982	1978
Reapplication of Surface Soils	1982	1982				1982	
Seedbed Preparation	1982	1982	1982	1978	1978	1982	1978
Seeding	1982	1982	1982	1978	1978	1982	1978
Mulching	1982	1982	1982			1982	
Fertilizing	1983	1983	1983	1979	1979	1983	1979
Shrub Planting	1983	1983	1983			1983	
Management [1] (e.g., irrigation, weed control)	As needed	As needed	As needed	As needed	As needed	As needed	As needed

[1] Management techniques will be applied as required. e. g., irrigation during excessive drought conditions or weed control when weeds become a problem.

[2] Plant site, adjacent ponds, and disposal area will not be reclaimed during the MDP unless RBOSP ceases mining activities. See Exhibit D, Subsection a.

(iii) Sequence of Reclamation Phases

Reclamation will proceed according to the sequence listed in Table E-2 beginning with segregation of topsoil in 1977 - 1978 and ending with shrub/tree planting in 1983. Management techniques (e.g., irrigation or weed control) will be implemented as existing environmental conditions necessitate.

g. Reclamation Plan

A description of each phase of the reclamation plan is presented in sequence. The reclamation plan has been developed for two general land disturbance types. Moderate disturbance include roads, transmission corridors, and the water injection system while major disturbances will occur at the run-of-mine disposal area, soil storage area and plant site. Moderate disturbances are those surface disturbances limited to narrow strips of land in which revegetation efforts will be more readily enhanced by natural revegetation from surrounding areas. Major disturbances include tracts of land which can benefit from more intensive revegetation efforts (e.g., topsoiling and shrub plantings). Specifics for each disturbance type will be noted, as appropriate, in the following discussion.

(i) Segregation of Surface Soil

Prior to construction and disposal activities, vegetation will be stripped and used to construct brush piles to provide alternate habitat for some displaced wildlife species. See RBOSP Wildlife Management Plan (RBOSP 1977b). Surface soils will then be stripped from the plant site, ponds, and disposal area (100 acres) and stockpiled adjacent to the run-of-mine ore disposal area (Exhibit F). The Rentsac, Rentsac-Piceance and Redcreek-Rentsac soils occur in this area (Figure C-5*) and have an average surface soil depth of 16, 16-50, and 16-31 centimeters respectively (Figure C-6*). These surface soils can provide a suitable plant growth medium and therefore these soils were selected to be stripped and segregated for future use as a "topsoiling" medium.

* See Volume II

(ii) Temporary Erosion Controls

The soil storage pile will be established in 1977 -1978 and will not be used until 1982. Therefore, it will be temporarily revegetated in the fall of 1978 to stabilize the pile, reduce wind and water erosion, and therefore reduce fugitive dust and water siltation.

The following seed mixture will be drilled on the soil storage pile by a rangeland drill.

Plant Species	Seeding Rates (lb/acre)
Yellow sweet clover	4
Barley	8
Western wheatgrass	6
Total	18

(iii) Grading

All corridors (moderate disturbance areas) will be graded following construction to establish contours comparable to existing topography. Slopes will not exceed a 2:1 grade.

The disposal pile, soil storage pile and plant site will eventually be graded to a slope not greater than 3:1 to permit operation of equipment.

Water bars will be constructed along roads, as appropriate, to prevent erosion.

(iv) Reapplication of Surface Soils

Since the run-of-mine ore will vary from 0 to 24 inch size material, the segregated surface soils will be used to evenly cover the run-of-mine ore disposal pile (25 - 30 acres). Sufficient material will be available to cover the disposal area with approximately 6-12 inches of surface soil material. Upon completion of mining activities, all plant site structures and adjacent ponds will be removed, graded, and topsoil applied before implementing revegetation procedures.

It is anticipated that corridors will not require surface soils in addition to those present at the location. If suitable material is necessary, surface soil can be stockpiled adjacent to the road and

graded over the berms immediately after construction is completed.

(v) Seedbed Preparation

All areas to be revegetated will be disked, graded, and, where appropriate, furrowed to provide a suitable seedbed and to enhance moisture retaining capabilities. Seedbed preparation will be done immediately prior to seeding in the fall. In areas where seed will be drilled all rocks and vegetative debris which might hamper equipment operation will be removed.

(vi) Seeding

Areas will be seeded as indicated in Table E-2. In western Colorado, seeding has been successful in late fall or early spring, although late fall (September 15 to November 15) is generally preferable (Cook et al, 1974). Seeding on Tract C-a will be carried out during the optimal fall period.

Since sagebrush and pinyon-juniper are the primary vegetation types to be disturbed plant species were selected which are common constituents of these types and which have demonstrated success in revegetation efforts on Tract C-a (RBOSP 1977a).

The seeding mixture to be applied to the disturbed areas will include the following grasses and forbs and will include shrubs for major disturbance areas. This seed mixture will provide both forage and browse for domestic livestock and wildlife.

Plant Species	Seeding Rate (lb/acre)
Luna pubescent wheatgrass	2.5
Western wheatgrass	3.5
Sodar streambank wheatgrass	2.0
Indian ricegrass	1.5
Green needlegrass	1.5
Manchar brome	1.5

Cicer milkvetch		1.5
Madrid yellow sweetclover		.75
Lewis flax		1.0
Winterfat*		1.0
Four-wing saltbush		1.0
Bitterbrush*		1.0
	Total	18.75

* Shrubs to be seeded on the ore disposal area.

Grass and forb seed of the selected plant species are now available from a variety of commercial sources in the Rocky Mountain area. Shrub seed availability is dependent on annual environmental conditions and therefore, winterfat may be particularly difficult to obtain in a given year. (Winterfat does not retain its viability when stored for more than several months). Bitterbrush and four-wing saltbush have better availability since it can be stored for several years without considerable effect on its viability.

Seeds will be broadcast or drilled depending on the terrain to be seeded. Drilling will be limited to terrain where machinery can be used. Drilling will be used on major disturbance areas because the slopes will not exceed a 3:1 grade. Broadcasting may be necessary on steeper slopes or in small areas (e.g., along corridors) where operation of equipment is not feasible or practical. In some areas where broadcasting is used, seed will be applied at twice the drilling rate (above) and covered by soil with a harrow or disk. All seeded areas, if practical, will be compacted using a cultipacker to provide a more favorable germination medium.

(vii) Mulching

Hydromulch will be applied to major disturbance areas to improve moisture retention and to prevent erosion. Hydromulch will be applied by conventional equipment at a rate of 1500 pounds/acre.

(viii) Fertilizers

Soil surveys and chemical analyses of the soils on Tract C-a indicate that most macro- and micronutrients occur in concentrations adequate to support normal plant growth. Exceptions include nitrogen and phosphorous which average 10 to 13 ppm (Exhibit I). Since the availability of these two macronutrients is important, particularly during early stages of revegetation, a minimum of 30 pounds/acre of elemental nitrogen and phosphorous will be applied to the surface soils of the disposal areas prior to seeding. Stockpiled soils will be tested prior to placement on the disposal piles to determine any variances from the projected 30 pounds/acre rate. Fertilizer rates will not exceed 60 to 80 pounds/acre (Cook et al. 1974), since such high rates may create conditions advantageous to less desirable species.

(ix) Shrub Planting

Containerized shrub seedlings have improved survival due to the larger root system which establishes during the first growing season. The following containerized shrubs (17 cubic inch size) will be planted on the north and east aspects of the major disturbance areas.

Plant Species	Planting Rate (individuals/acre)
True mountain mahogany	200-500
Bitterbrush	100-200

(This species will also be seeded).

Shrubs will not be planted along corridors (moderate disturbance areas) due to the limited area of disturbance.

(x) Management

Irrigation may be necessary when extreme drought conditions (e.g.,

summer 1977) exist during the first growing season. The RBOSP experimental revegetation results (RBOSP 1977a) indicate that normal precipiation in the Tract C-a vicinity (Exhibit K) is sufficient to establish vegetation similar to that presently existing. Therefore, irrigation is not expected to be required during normal precipitation years.

Prompt revegetation in disturbed areas and proper management should eliminate the need to control undesirable plants with herbicides. Any weed control before planting will be done by mechanical methods such as tillage. Judicious use of selected herbicides may be beneficial in controlling weeds after establishment of vegetation.

Fencing may be required in the disposal area since the availability of palatable plant species may attract large herbivores (primarily feral horses and domestic livestock); however, such fencing is not planned at this time. The fencing of small areas along roads and around buildings is not feasible.

LITERATURE CITED

Bureau of Land Management and Colorado Division of Wildlife. 1977. Piceance Basin wildlife habitat management plan. (CO-1 WHA-1). Denver, CO.

Cook, C.W., R.M. Hyde and P.L. Sims. 1974. Guidelines for revegetation and stabilization of surface mined areas in the western states. Colorado State University Range Science Department, Science Series No. 16, Fort Collins, Colorado. 74p.

RBOSP. 1977a. Progress Report 9. Gulf-Standard, Denver, Colorado.

RBOSP. 1977b. Revised Detailed Development Plan. Gulf-Standard, Denver, Colorado. Attachment D-1.

U.S. Department of Interior. 1974. Tract C-a Oil Shale Lease Environmental Stipulations and References. USDI Bureau of Land Management, Washington. Attachment A-1.

EXHIBIT
f

EXHIBIT f

RECLAMATION PLAN MAP

EXHIBIT F - RECLAMATION PLAN MAP

Reclamation activities will be conducted primarily during 1978 for the roads, transmission corridors and water injection system (moderate disturbance areas). The disposal pile, soil storage areas, plant site and adjacent pond areas (major disturbance areas) will be reclaimed in 1982 - 1983 if the Tract C-a lease is surrendered by RBOSP at the end of the MDP. The Corral Gulch Reservoir will be a permanent reservoir and therefore not scheduled for reclamation due to its beneficial effects on existing domestic animals and wildlife.

a. Map of Affected Lands

Figure F-1 (inserted in pocket) presents the locations of the affected lands on Tract C-a and indicates the timing of the proposed reclamation activities. See Exhibit E for the detailed reclamation plan and Figure C-3* for the sequence of mining activities. The acreages associated with these disturbed lands is presented in Table E-1.

Figure F-1* depicts the final topography and aspect of disturbed land (e.g., the disposal pile will have an approximate 3:1 slope and side-slopes are generally north-facing). Elevations have been indicated at several locations in the plant site area (e.g., top of ore pile, process area, and mine service retention pond) to present additional reference points for final topography at the time of reclamation.

b. Proposed Final Land Use

The proposed final land use of the moderate disturbance areas is indicated on Figure F-1* as rangeland/wildlife habitat. The major disturbance areas will be used for industrial purposes unless the Tract C-a lease is surrendered by RBOSP. In this event these areas would be reclaimed to support range/ wildlife uses.

* See Volume II

EXHIBIT
G

EXHIBIT G

WATER INFORMATION

EXHIBIT G - WATER INFORMATION

An Application for a Subsurface Disposal Permit together with a report integrated therein entitled Dewatering, Reinjection and Supplemental Injection Systems for Modular Phase, Modified In Situ Development of Tract C-a, hereafter Reinjection Report was submitted to the Colorado Department of Health, Water Quality Control Commission, on September 9, 1977. It was discussed with the administrators of the Water Quality Control Division that the Reinjection Report portrays the maximum probable amount of supplemental injection to mitigate effects of dewatering and that the system actually adopted may be a compromise plan which would also minimize use of off-tract, imported water. The complete Reinjection Report is included here as Attachment G-1.

The reinjection report, and the figures included therein, is fully responsive to Items a, b, and c of this section for the period said report covers, that is, the 3.75 years of modular phase development (MDP) plus a one year period of supplemental injection necessary to accomplish full recovery of the groundwater and surface water regimes after it is assumed all MDP mining and dewatering activities have ceased.

a. Statement of Effect (see b below)

b. Effects of proposed development on surface and groundwater systems

Extraction of oil shale from Tract C-a by means of the modified in situ (MIS) method will require dewatering of the mine area to prevent flooding of the mine shaft. Since the underground aquifers are hydrologically connected, the withdrawal of water requires compensatory replacement to prevent depletions of the surface water system. RBOSP has devised a dewatering and reinjection system designed to provide for dewatering of the mine and to mitigate the adverse effects of this dewatering process (Attachment G-1).

Locations of information required for Exhibit G are given below.

(i) Locations of Water Resources in the Proposed Mining Area

See Figure G-1 and Figure C-2* for locations of surface streams. See Section 5, Chapter 1 text and Figure 5-1-1 of Section 5 in Attachment G-1 for locations of springs, wells, and water rights in the project area.

(ii) Aquifers in the Study Area

Alluvial, perched, and deep bedrock aquifers are present in the Piceance Creek hydrologic basin (Figure G-2). However, the only major aquifers found in the vicinity of Tract C-a were the alluvial and deep bedrock aquifers. Locations of the alluvial aquifer system are shown on Figure G-1.

The two major bedrock aquifer systems present under Tract C-a are shown on Figure G-3. The upper aquifer system occurs in the vicinity of the Mahogany zone. The lower aquifer system is associated with the R-3 zone and in some cases is as deep as the Blue marker. Both aquifer systems are artesian. With the exception of the northeast corner of Tract C-a, the upper aquifer system has a higher potentiometric level than the lower aquifer system. On the average, the difference between the potentiometric levels is approximately 150 feet. Although quite variable from place-to-place, the aquifers each have an average thickness of about 220 feet.

There appears to be a connection between the upper and lower aquifers in the northeast corner of the Tract in the area of CE 702, G-S 6, and TO 3, indicated by the drawdown and recovery of the upper aquifer during the lower aquifer pumping tests of G-S D19 and G-S D18 simultaneously.

This interconnection may be the result of faults in the area, inadequate isolation of the two aquifers in one of the three holes located in the northeast corner of the tract, and/or possible man-made fracturing as a

* See Volume II

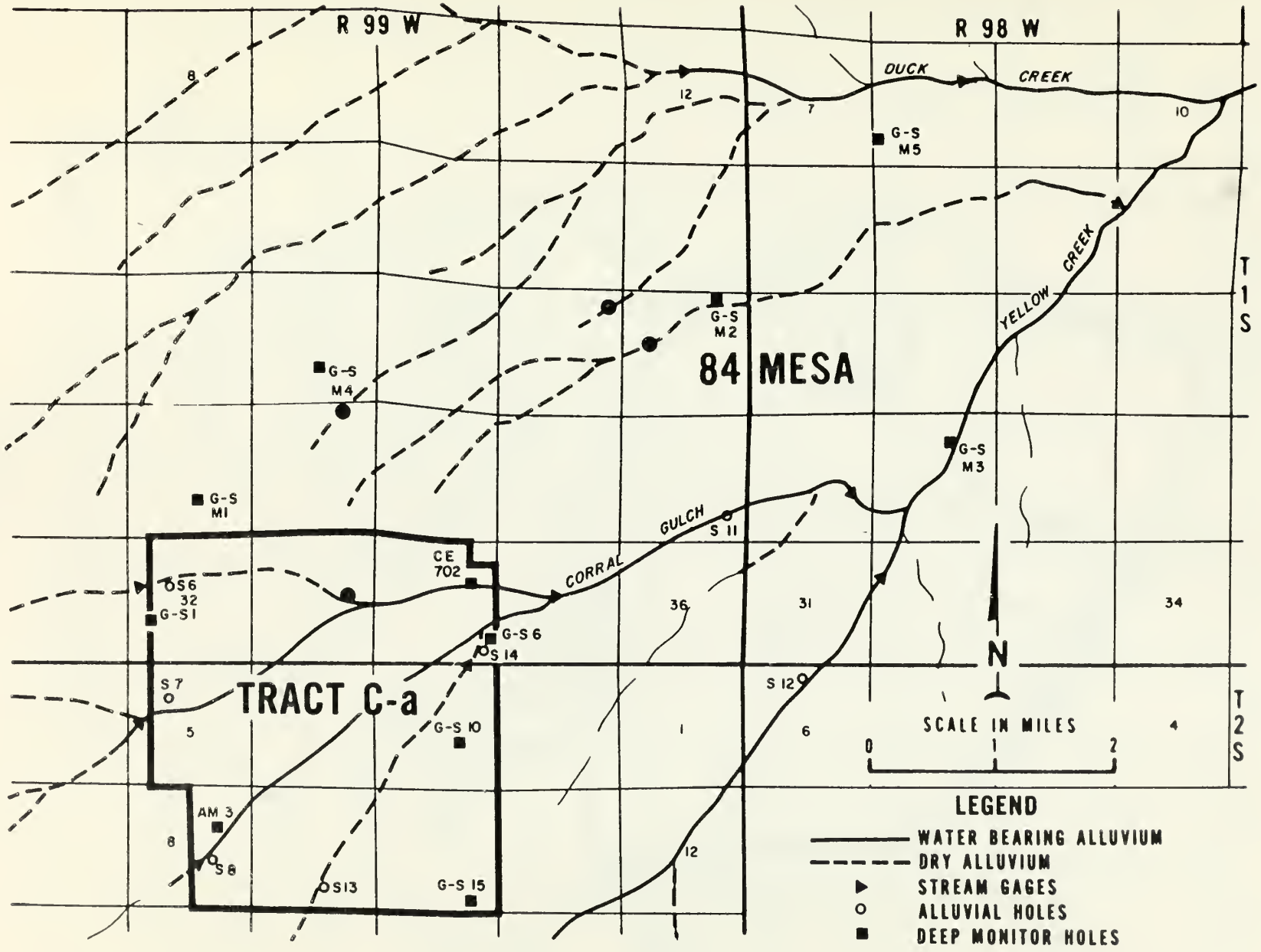


Figure G-1
LOCATIONS OF SURFACE STREAMS IN STUDY AREA

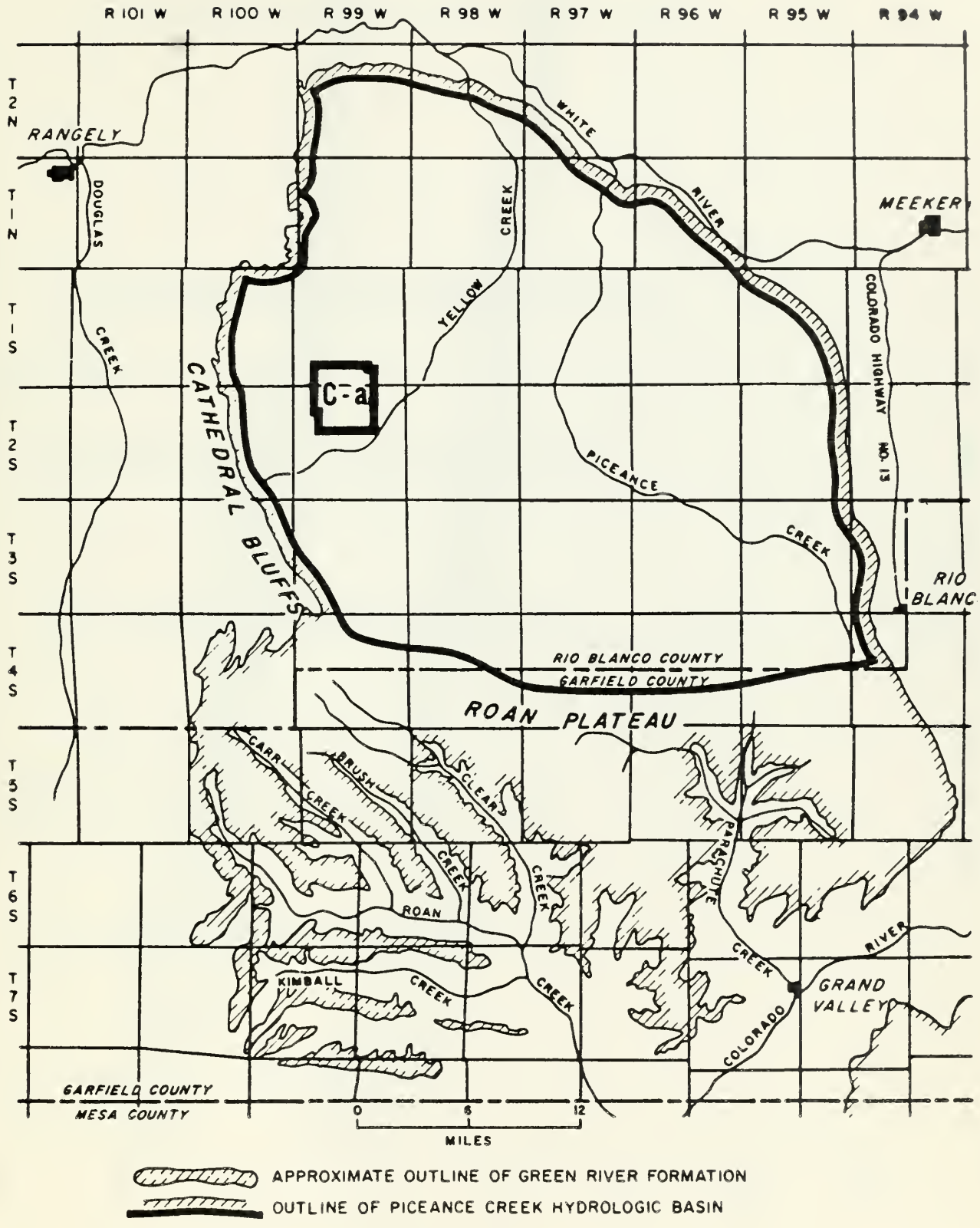


Figure G-2

PICEANCE CREEK HYDROLOGIC BASIN

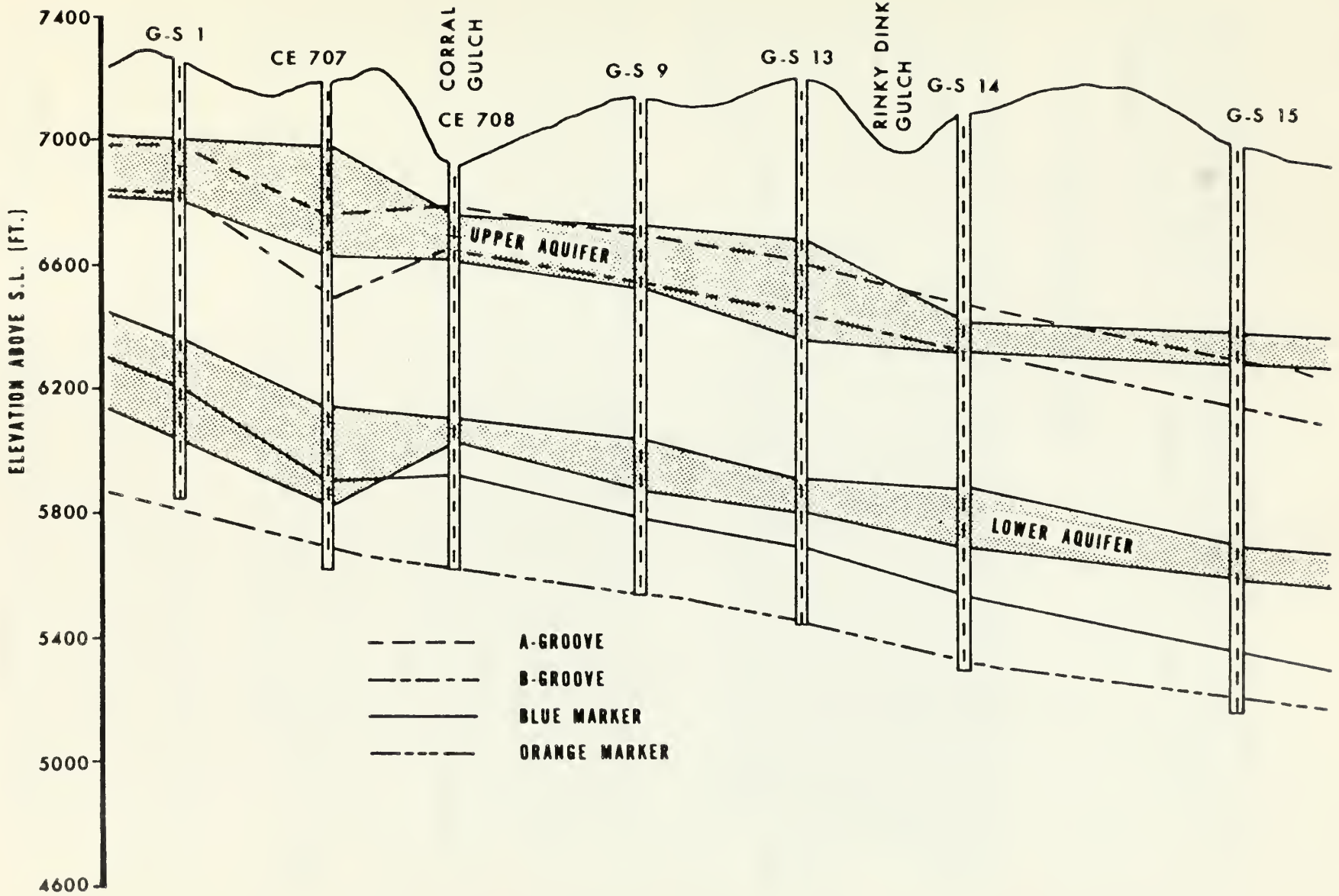


Figure G-3

UPPER AND LOWER BEDROCK AQUIFERS UNDER TRACT C-a

result of experimental fracturing work done by WRD-USGS in 1973. For additional information on the aquifers under Tract C-a, consult Section 2 Chapter 3 of the RBOSP Final Environmental Baseline Report (1977) Attachment G-2.

(iii) Water Resource Management

The water quality control plan to be employed in developing Tract C-a is an adaptation of the American Petroleum Institute's zero discharge water concept. A portion of the water produced will be consumptively used either through evaporation of the atmosphere, through processing needs, through dust control needs, or by absorption in the processed shale disposal pile. The remaining groundwater produced from dewatering wells and mine seepage will be reinjected into the groundwater aquifers. (See Attachment G-1, Section 6-Dewatering, Distribution and Reinjection Systems).

The water control system will be designed to control surface runoff water, mine dewatering and the processing of waste waters. Surface water originating outside the Tract C-a project area will be diverted around the mine site, processing facility and disposal areas. Surface water originating within the project area will be controlled by a series of collection ditches and retention dams and will be recycled to the process water system, used for dust control or evaporated.

A majority of the groundwater from the mine dewatering wells will be pumped and reinjected into the groundwater aquifers on the tract. Some of the groundwater may be treated to provide potable water.

Part of the mine seepage water will be used for dust control. The remainder will be treated and used for process needs and fire protection or reinjected with the excess water from dewatering wells.

MIS retort water will be evaporated in a thermal oxidizer during the Modular Development Phase (MDP). Most of the groundwater existing

in the vicinity of Tract C-a is part of a basin-wide aquifer system, wherein the water is in a state of transient storage and moving slowly towards discharge into surface streams in the area. Because most of the groundwater that is removed to allow an underground mining and MIS retorting operation will be reinjected, the overall effect on the aquifer system will be minimized.

Retention ponds will be lined with impermeable material. Most other ponds and ditches probably will not be lined unless further investigation indicates that it will be necessary.

Dams creating ponds or reservoirs will be constructed in accordance with standards and specifications approved by the Colorado State Engineer and the Area Oil Shale Supervisor (AOSS). Materials native to the region will be used wherever feasible. Cores of dams will be constructed of impervious materials.

For further information on proposed mitigation measures to prevent water pollution see the RBOSP Revised DDP, Section 6, Chapter 6 - Water Quality Control, and Chapter 7 - Oil and Hazardous Material Control. Attachment 1.

c. Water Requirements

Project water requirements, including flow rates and annual volumes required for development and mining activities of the Modular Development Phase are given in Section 6, Chapter 1, of Attachment G-1. Available data indicate that, except during drought stress periods, revegetation can be accomplished without irrigation.

d. Water Sources and Water Rights

Figure 5-1-1 in Attachment G-1 shows all water resources within two miles of the boundaries of Tract C-a, including adjudicated water rights and all natural springs. Figure D-2 submitted herewith shows the source of water supply planned by the Operator for Modular Development

Phase. It will be noted that for the MDP, the source of water supply is on-tract water tributaries, including Box Elder Gulch which would be collected by a small impoundment, the Corral Gulch Reservoir, located about one-half mile east of the tract and diverted for use or supplemental injection via pipeline (Figure C-3*). (See Figure B-1 and D-2 for Corral Gulch Reservoir.)

Since Operators plan to reinject groundwater produced in dewatering as well as tentatively plan to inject relatively large amounts of supplemental water, no negative effects, such as causing diminition of flow of regional streams or springs, are expected to occur. There are no active water rights or use of water within the sphere found to be affected by dewatering, some two-thirds mile radius from the area to be mined during the MDP. Water rights of sufficiently early priority will, of course, need to be acquired to permit diversions as contemplated. The water rights which Operators hold on the White River, as well as optioned water rights being transferred, are adequate to ensure dependable yield as well as to preclude injury to other vested water rights through out-of-priority diversion.

The Reinjection Report (Figure 5-2-4) describes the project water requirements and the rates and amounts of water diversion planned through the MDP from the various sources. Figure 5-2-1 together with related narrative specifications demonstrate the physical adequacy of the works planned. Analyses utilizing a CORSIM II subroutine will be made of the dependability of yield, notwithstanding the demands of senior water rights. The analyses will then be expanded to identify the water rights which must be acquired and changed to the proposed industrial use to assure legal, in-priority use of the proposed water sources.

It is contemplated that all water rights presently being utilized on Yellow Creek and its tributaries will be acquired, through purchase or lease, as timely, since Yellow Creek will not sustain the proposed on-tract diversion together with an irrigation burden. Although many of the rights on Yellow Creek indicate no use for more than a decade, thus

* See Volume II

implying abandonment, it is planned that these rights will also be leased and changed (temporarily) for use at the Corral Gulch diversion point or at other alternative diversion and/or storage sites which may be implemented along Yellow Creek or its tributaries.

In addition to the Subsurface Disposal Permit and related system water rights planned to be acquired, Operators plan to submit within the immediate future an application for an NPDES permit for the MDP development dewatering system and related surface discharge facilities to be implemented in the event such alternative system is proven more feasible through subsequent studies to be made. Short form NPDES applications have been submitted (and partially issued) for temporary discharge of water anticipated to be associated with air drilling and pump testing of wells, including dewatering and reinjection wells and monitoring holes, as shown on Figure 6-3-1 of Attachment G-1.

Operators water supply plans are reflected and described by three documents as follows and which are available on request:

1. The decree entered by the Court in Operators groundwater Case No. W-2514 captioned "Findings of Fact, Conclusions of Law, and Judgment".

2. An Application for change of Water Rights and a stipulation entered with certain opposing parties in Operators Case No. W-2686 before the Water Court.

3. Operators Application for a Section 404 permit for stage construction of the Yellow Creek Diversion and storage works planned to be submitted by Operators to the Department of the Army within the immediate future.

Water studies have been made, and reports of such studies as listed below can be made available upon request of the Board, demonstrating the

adequacy of the water rights and of the proposed system to supply water needs of the project, including potential surplus water and storage capacity it is contemplated may be utilized in joint development with the industry and/or irrigation interests. Such reports include the following:

1. Rio Blanco Oil Shale Project Water Supply Studies - Phase B - ROMPOCO Water Rights Yield Analysis (First Phase).

2. Rio Blanco Oil Shale Project Water Supply Studies - Phase H - Evaluation of Alternative Plans.

3. Rio Blanco Oil Shale Project Water Supply Studies - Phase D, J and L - Transfer and Net Yield of ROMPOCO Rights.

4. Rio Blanco Oil Shale Project Water Supply Studies - Phase F - Evaluation of Effect of Colorado River Compacts on White River Water Supplies.

e. Permit Application

RBOSP officially applied for a "Subsurface Disposal System Permit" pursuant to the Colorado Water Quality Control Act of 1973, as amended, and the regulations promulgated under the "Rules for Subsurface Disposal Systems" on September 9, 1977. Attachment G-1 is the report which was a supplement to that application. It should be pointed out that the Piceance Creek Pipeline water supply option has a low probability of implementation, especially during the MDP. In addition, the Black Sulphur Creek Pipeline has a very low probability of implementation, a much lower probability than the Piceance Creek Pipeline.

f. (See Subsection d above).

LITERATURE CITED

RBOSP. 1977. Final Environmental Baseline Report. Gulf-Standard, Denver, Colorado. Attachment G-2.

EXHIBIT
H

EXHIBIT H

WILDLIFE INFORMATION

EXHIBIT H - WILDLIFE INFORMATION

Environmental baseline studies were conducted on the proposed mining site (Tract C-a) and a 5-mile radius (Figure B-1*, inserted in pocket) from October, 1974 through September, 1976. These studies included small mammal population studies, predatory mammal censuses, large mammal (mule deer, elk, feral horses, and domestic cattle) surveys, avifauna surveys, invertebrate surveys, and herpetofauna studies. Aquatic habitat in the Tract C-a vicinity is limited to a few ephemeral streams and small ponds; no fishery habitat occurs. The present discussion will be limited primarily to the terrestrial wildlife resources. The wildlife species identified during the baseline studies are listed in Attachments H-1, H-2, and H-3, Volume I, pages H-26 thru H-37. The wildlife statement provided by the Colorado Division of Wildlife (CDOW) is presented in Attachment H-4, pages H-38 thru H-40.

a. Description of Wildlife Resources in the Area

(i) Mule Deer

Mule deer are the most economically important wildlife species in the Tract C-a area. Tract C-a lies within CDOW Game Management Unit 22 in the Piceance Creek Basin. Game Management Unit 22 has been listed among the top ten (rank ranged from 1st to 9th) units in the state for the highest number of hunters and largest number of deer harvested for several years (Colorado Division of Game, Fish and Parks 1971, 1972; Colorado Division of Wildlife 1973, 1974, 1975, 1976). The CDOW estimated a harvest of 1,982 deer by 4,617 hunters during the 1974 rifle season and 2,191 deer by 4,347 hunters during the 1975 season on the 1,033 square miles within the Unit (Colorado Division of Wildlife 1975, 1976). Hunters are not evenly distributed within the unit so the percentage of hunters using Tract C-a and the surrounding area cannot be accurately determined. Observations of number of hunters during the 1975 and 1976 deer season, however, indicate that the study area receives moderate use from non-resident and resident hunters.

*See Volume II

The Piceance Creek Basin serves as an important winter range for the migratory Piceance Basin deer herd. Mule deer are not evenly distributed throughout the Piceance Basin and the CDOW is presently conducting studies to delineate deer sub-population boundaries and concentration areas on the Piceance winter range (Bartmann 1975). The deer density on the western portion of the basin is generally considered to be lighter than in the central and eastern portions during most winters (Bartmann 1974, 1976). Baker and McKean (1971) indicate that the entire area of Unit 22 can be used as summer range.

The mule deer distribution patterns observed during the two winters of baseline study, in combination with CDOW information, indicate that Tract C-a could be termed transition and upper winter range. During mild winters, Tract C-a and nearby areas are used more extensively than during severe winters. Mule deer also use the study area as they move between summer and winter ranges.

Results of baseline studies show that deer begin moving into the area in October during their migration from higher elevations west and south of Tract C-a to winter range north and east of the tract. This movement is a gradual drift of the animals, probably in response to temperature declines and increased snow depth in their higher-elevation summer range and so movements may vary from year to year. Mule deer sometimes use Tract C-a throughout the winter but as snow levels increase, they concentrate in the pinyon-juniper and sagebrush vegetation types northeast of the tract. During late April and early May, the largest herds of mule deer characteristically occur in the meadows and bottomlands east of the tract. Movement back to the summer range takes place over an extended period. The deer gradually drift to the higher elevations as individuals and small groups. By late May, most of the deer in the study area have returned to their summer range (higher elevations west and south of Tract C-a). Numbers of deer seen in the vicinity of Tract C-a during aerial surveys are shown in Tables H-1 and H-2. As these tables show, during the baseline period the number of deer using the tract proper was much lower than for areas off tract and outside the proposed mining site. Few mule

TABLE H-1

MULE DEER OBSERVED ON FOUR CENSUS AREAS DURING 11 SURVEY PERIODS, WINTER, 1974-1975 FOR RBOSP

Date of Census	Tract C-a	North of[1] Tract	East	West	Total Observed
November 8, 1974	14	--	7	12	33
November 21, 1974	0	--	1	2	3
December 9, 1974	12	--	103	64	179
December 30, 1974	60	--	105	130	295
January 14, 1975	33	--	62	16	111
February 1, 1975	24	4	95	2	125
February 12, 1975	30	14	75	0	119
March 4, 1975	7	8	229	0	244
March 13, 1975	14	14	296	0	324
April 3, 1975	24	10	220	4	258
April 14, 1975	12	19	469	0	500

1/ Censuses of this area commenced during February, 1975.

TABLE H-2

MULE DEER OBSERVED DURING 16 SURVEY FLIGHTS JUNE 1975 TO SEPTEMBER 1976 FOR RBOSP

Date of Census	Transects for Tract C-a and Land to the North and South	Transects East of Tract C-a	Transects West of Tract C-a	Total
June 26, 1975	0	0	0	0
August 18, 1975	0	0	0	0
November 6, 1975	4	22	6	32
November 24, 1975	8	54	71	133
December 4, 1975	6	40	42	88
December 18, 1975	11	214	142	367
January 5, 1976	9	117	44	170
January 29, 1976	41	143	0	184
February 23, 1976	2	284	0	286
March 8, 1976	0	215	0	215
March 17, 1976	12	172	0	184
March 29, 1976	55	554	0	609
April 8, 1976	28	753	5	786
April 25, 1976	36	368	48	452
June 10, 1976	0	0	2	2
August 9, 1976	1	0	2	3

deer remain in the vicinity of Tract C-a during the summer and these are scattered throughout the areas of higher elevation west of Tract C-a. Summer mule deer numbers were low, and their distribution was scattered during baseline studies. The mixture of aspen, Douglas-fir, sagebrush, and mixed brush vegetation types, combined with the broad range of slopes and aspects occurring west of Tract C-a, affords a variety of micro-habitats for mule deer. Eighty-five to 92 percent of the mule deer pellet groups counted during both summers of study were located in the mixed brush vegetation type west of Tract C-a.

(ii) Elk

No elk were sighted on Tract C-a during the two years of baseline studies. A small number (15 to 20) of animals was counted in areas to the west, north, and south of the tract. These animals were generally located in mixed brush, aspen or Douglas-fir west of Tract C-a (Cathedral Bluffs) or in pinyon-juniper types north and sagebrush types south of Tract C-a. Most elk sighted during the summer were southwest of the tract. Elk tracks were observed at the spring in Stake Springs Draw south of Tract C-a during both years of baseline studies in spring and summer.

Baker and McKean (1971) indicated that elk numbers within Unit 22 were low and those animals wintering in the Cathedral Bluffs-Calamity Ridge area on the western edge of the unit (near Tract C-a) probably summered to the south along the crest of the Roan Plateau. The winter populations in the unit appear to be greater than summer populations, probably due to movements into the unit from surrounding areas. The number of elk harvested in Unit 22 for 1971-75 were 12, 0, 67, 209, and 175, respectively (Colorado Division of Game, Fish, and Parks 1972; Colorado Division of Wildlife 1973, 1974, 1975, 1976). The statistics indicate a large increase in harvest since 1973.

(iii) Feral Horses

Numerous bands of feral horses range over the study area, including Tract C-a. Most of the horses were located in the area bounded by Big Duck Creek, Yellow Creek, Stake Springs Draw (left fork), and the Cathedral Bluffs (Figure B-1), although scattered individuals or small bands were occasionally observed outside this area. In contrast to the variable seasonal distribution of mule deer, feral horses are present throughout the year. The largest number of horses recorded during baseline aerial surveys was 115 individuals on April 25, 1976 (Table H-3). This does not represent the total population in the study area, however, since a herd of at least 16 animals is known to frequent Dead Horse Ridge north of Tract C-a and bachelor studs which were not observed on that survey are scattered throughout the area. The area is estimated to support a minimum of 135 head of wild horses. BLM personnel estimated that 148 horses occupied the Square S and Box Elder grazing allotments (major portions of which encompass the study area) during the summer of 1975 (personal communication, B. Lawhorn, BLM, Meeker, 1976).

During the winter, many of the horses forage along Cathedral Bluffs or on windswept ridge tops where forage is not covered by snow. The animals are located on these areas mainly during relatively mild weather conditions and move to dense brush, ravines, or the lee side of ridges during inclement weather. The feral horses occupying 84 Mesa and those remaining at the lower elevations in and near Tract C-a seek shelter in pinyon-juniper stands or gullies and forage in the mixed brush and sagebrush vegetation types in these areas.

(iv) Small and Medium Sized Mammals

Thirty species of small and medium-sized mammals (Attachment H-2) occur in the vicinity of Tract C-a. Generally, vegetation types with the greatest amount of shrub cover (greasewood/sagebrush, rabbitbrush, and mixed brush) exhibited the greatest apparent abundances of small mammals. A summary of small mammal trapping results is presented in Table H-4. The least chipmunk and deer mouse were the two most abundant species trapped in these and many other

TABLE H-3

NUMBER OF FERAL HORSES OBSERVED DURING TWENTY AERIAL SURVEYS DURING 1974-1976 FOR RBOSP

Date	Horses Observed			
	Total	Adult	Juvenile	Unidentified
November 8, 1974	108	24	15	69
December 30, 1974	86	8	2	76
March 4, 1975	41	16	4	21
April 14, 1975	74	69	5	0
June 26, 1975	93	69	24	0
August 18, 1975	63	55	8	0
November 6, 1975	55	24	1	30
November 24, 1975	87	40	4	43
December 4, 1975	69	56	8	5
December 18, 1975	59	11	2	46
January 5, 1976	65	64	1	0
January 29, 1976	47	47	0	0
February 23, 1976	45	31	4	10
March 8, 1976	36	27	1	8
March 17, 1976	50	26	2	22
March 29, 1976	29	0	0	29
April 8, 1976	74	74	0	0
April 25, 1976	115	84	8	23
June 10, 1976	98	76	8	23
August 9, 1976	39	37	2	0

TABLE H-4

SMALL MAMMAL TRAPPING SUMMARY FOR ALL GRIDS DURING EACH SAMPLING PERIOD FOR RBOSP

Grid/Vegetation Type	Individuals captured of all species per 100 trap nights											
	Oct. 1974	Dec. 1974	May 1975	July 1975	Sept. 1975	Dec. 1975	May 1976	July 1976	Sept. 1976	Average	%RA	Rank
1 Bottomland meadow	10.91	14.55	6.67	5.05	3.64	0.61	3.03	30.91	15.76	10.36	4.36	14
2 Upland sagebrush	10.91	4.85	13.33	20.61	17.58	1.21	17.58	37.58	23.64	16.36	6.88	9
3 Rabbitbrush	23.64	15.15	35.76	12.73	23.03	3.64	24.85	39.83	34.55	24.37	10.25	1
4 P-J/mixed brush	24.24	2.42	22.42	13.33	12.73	6.06	30.91	38.18	26.67	19.66	8.27	4
5 Mixed brush	20.61	1.21	23.03	8.48	33.33	0.00	23.64	35.76	29.70	19.53	8.21	5
6 P-J/sagebrush	18.18	6.06	21.21	15.15	13.94	3.64	24.85	34.20	35.15	19.79	8.33	3
7 Bald	5.45	0.00	9.09	8.48	9.70	9.70	12.73	60.61	13.94	16.38	6.89	8
A Bottomland sagebrush	22.26	12.73	12.33	12.63	26.47	2.42	14.89	38.35	27.52	21.10	8.88	2
B P-J (South Slope)	16.54	9.09	14.14	16.09	14.44	5.45	14.59	26.32	22.71	17.13	7.21	7
C P-J (North Slope)	15.04	1.21	9.02	14.59	11.28	2.42	13.83	31.73	22.41	15.85	6.67	10
D Upland sagebrush	15.34	1.21	9.77	7.97	6.47	0.61	14.14	30.33	19.85	14.34	6.03	11
E Mixed brush	8.57	0.00	13.08	11.13	17.44	6.06	14.59	44.68	11.73	17.81	7.49	6
F Douglas-fir	8.98	7.88	8.52	7.21	8.85	4.85	8.52	29.84	13.44	11.48	4.83	13
G Aspen	*	*	10.49	6.56	10.49	6.67	13.44	29.18	15.08	13.58	5.71	12
Average	15.39	5.87	12.40	11.39	14.17	3.33	14.38	34.04	20.24	16.95		
% Relative Abundance	11.73	4.48	9.45	8.68	10.80	2.54	10.96	25.95	15.42			
Rank	3	8	6	7	5	9	4	1	2			

*Grid not sampled.

vegetation types. They comprised over 80 percent of all small mammals captured in the study area.

Few species of small mammals were captured and relative abundances were apparently lower at higher elevations (above 8,000 feet). Two species, the red-backed vole and the red squirrel, are reportedly limited to aspen and Douglas-fir stands similar to those found on Cathedral Bluffs.

More species of small mammals were captured in pinyon-juniper than in any other vegetation type, probably because of the greater habitat heterogeneity. Two species, the pinon mouse and Colorado chipmunk, were found only in this type, and the bushytailed woodrat and golden-mantled ground squirrel were captured more frequently in pinyon-juniper habitat.

Less abundant small mammal species include the thirteen-lined ground squirrel, long-tailed vole, montane vole, and sagebrush vole. The northern pocket gopher and porcupine are also residents of the Tract C-a area as are three lagomorph species: Nuttall's cottontail, the blacktailed jackrabbit, and the white-tailed jackrabbit.

Three insectivores, the masked shrew, wandering shrew and Merriam's shrew (a first record for the Piceance Creek Basin) have been identified to date (R. Finley, United States Fish and Wildlife Service (USFWS), 1975, personal communication). Seven bat species: the hoary bat, big brown bat, silver-haired bat, and four species of myotis have also been found in the study area.

(v) Predatory Mammals

Predatory mammals reported from the Tract C-a vicinity during baseline studies included: the coyote, long-tailed weasel, shorttailed weasel, bobcat, badger, and skunk (Attachment H-2). Although the mountain lion, black bear, and ring-tail have not been observed in the study area, they do occur in the region

and may occasionally venture onto Tract C-a (Baker and McKean 1971).

Coyotes are active year-round in all habitat types in the Tract C-a study area. Interviews with area cattle ranchers indicate no problem with domestic livestock depredation by the coyote. Sheep do not graze in the area.

Weasels were observed in all vegetation types but activity was most commonly noted in vegetation types having the densest shrub cover (i.e., sagebrush, rabbitbrush, and mixed brush). A single badger was observed on Wolf Ridge late at night during February, 1975. The burrowing activity of this species is evident in many places throughout the study area.

Bobcat sign was noted during winter track count studies and observed opportunistically during various other field activities; a bobcat skull was also found. There have been no verified reports of black bear or mountain lion on the study area. Local ranchers, however, have reported occasional sightings of both species along Cathedral Bluffs. It can be assumed that while these animals probably do not reside in the immediate Tract C-a area, they may pass through occasionally.

(vi) Avifauna

During baseline studies, 139 avian species (Attachment H-1) were identified in the study area. Species sighted included songbirds, gamebirds, waterfowl, and raptors. Total seasonal avian densities for all habitats within the study area are presented in Table H-5.

Songbirds - The following songbird species are common year-round residents: common flicker, horned lark, Steller's jay, scrub jay, pinyon jay, black-billed magpie, Clark's nutcracker, black-capped chickadee, mountain chickadee, plain titmouse, redbreasted nuthatch, and gray-headed junco. Riparian habitats support the greatest bird density and diversity on an annual basis, while sagebrush and rabbitbrush support the lowest numbers of species and individuals.

TABLE H-5

TOTAL AVIAN DENSITIES (INDIVIDUALS PER HECTARE) IN 15 HABITAT TYPES SAMPLED DURING 1974-1976 FOR RBOSP

Habitat	Sampling Period								
	10/74	12/74	2/75	4/75	6/75	10/75	2/76-3/76	4/76	6/76
Agriculture	2.51	0.26	0.82	1.16	6.72	1.18	2.62	3.43	10.29
Upland sagebrush	0.66	0.00	0.00	0.61	1.50	2.01	3.01	0.25	5.47
Rabbitbrush	6.90	0.00	1.74	0.74	2.50	8.62	0.20	2.09	7.23
Pinyon-juniper/ mixed brush	0.46	0.00	0.00	0.00	2.49	1.82	3.41	0.92	9.34
Mixed brush	.92	1.02	0.05	0.00	1.99	3.38	0.58	0.56	4.98
Pinyon-juniper sagebrush	13.16	0.41	0.00	0.00	4.30	4.59	0.42	7.43	8.71
Bald	2.05	*	0.00	0.15	2.24	4.71	*	1.38	2.12
Bottomland sagebrush	1.52	0.05	0.00	13.92	6.54	6.50	1.36	2.41	3.60
Pinyon-juniper	0.26	0.00	0.00	0.77	4.41	0.92	2.19	0.36	5.94
Pinyon-juniper	2.26	0.26	4.57	0.00	9.96	4.82	1.27	0.15	12.12
Upland sagebrush	0.00	*	0.00	0.00	5.18	5.54	0.20	2.03	4.39
Mixed brush	24.59	*	7.38	3.69	3.69	5.02	0.36	4.76	9.22
Douglas-fir	4.79	*	14.89	3.83	6.89	2.70	13.92	2.01	13.57
Aspen	3.56	*	0.87	6.26	9.40	2.38	*	3.78	6.37
Riparian	11.83	*	0.00	22.87	21.39	5.05	0.92	3.76	24.68

* Habitat not sampled.

During summer, the largest number of birds were encountered in riparian, agricultural, Douglas-fir, aspen, and pinyon-juniper vegetation types. During June, the most common summer residents migrating into the area were the mountain bluebird, green-tailed towhee, chipping sparrow, Brewer's sparrow, and vesper sparrow. A sparseness of birds was exhibited in midwinter. In spring and fall a composite of winter and summer birds occurs.

Gamebirds - Three gamebird species are known to inhabit the study area; the sage grouse, blue grouse, and mourning dove. The sage grouse is a common year-round resident within areas of upland sagebrush and mixed brush habitats primarily in the southwest portions of the study area just off Tract C-a. It also winters in the lower elevations of the study area. Throughout its range on the study area, the sage grouse is intimately associated with sagebrush the year round. Although the actual population size is unknown, the southwest section of the study area appears to support the highest density of breeding sage grouse in the region encompassing Roan Creek and Piceance Creek drainages (personal communication, Ron Krager, CDOW, Meeker, 1976).

Blue grouse are common year-round residents along Cathedral Bluffs but not on Tract C-a. In this area, the blue grouse primarily inhabits bald, mixed brush, aspen/mixed brush, and Douglas-fir/mixed brush ecotonal areas. Throughout its range on the study area, it is always in proximity of Douglas-fir stands. Douglas-fir needles, buds, twigs, and cones are major winter food items for blue grouse. As winter ends, the birds migrate from the Douglas-fir stands to areas of more open cover such as the forest-edge habitats. The population of blue grouse residing on the study area is probably small in relation to other areas in northwestern Colorado due to the limited amount of preferred blue grouse habitat.

The mourning dove is the most widely distributed gamebird within the study area during the breeding and migration periods. During these seasons, it was observed in a variety of habitats, with the greater number of individuals noted in pinyon-juniper and upland sagebrush vegetation types. The mourning

dove is herbivorous in its food requirements and probably feeds on the variety of herbaceous species found on the study area. The population of mourning doves on the study area is probably small in relation to other parts of the Piceance Creek and Roan Creek drainages that have a greater amount of agriculture habitat.

Waterfowl and Shorebirds - In the Tract C-a study area, a few surface ponds and intermittent streams create isolated islands of habitat for waterfowl and shorebirds. Because surface water is restricted in distribution in northwestern Colorado, such habitat types have an unusually high ecological value in this region. Fourteen waterfowl and shorebird species (Attachment H-1) were recorded within the Tract C-a vicinity, primarily associated with the Stake Springs Draw impoundment. Although usage of the area by waterfowl and shorebirds is greater during late spring and summer than during fall, the overall waterbird population within the study area is small. The mallard, green-winged teal, blue-winged teal, and killdeer were the most common waterfowl and shorebirds utilizing surface waters of the area.

Two migrant shorebird species, the greater sandhill crane and the whooping crane were sighted several miles off the tract. These species appear on either state or federal threatened or endangered lists and are discussed separately.

Raptorial Birds - The status, occurrence and number of nests located on the study area for all raptor species known to occur on the study area are presented in Table H-6.

Fourteen diurnal hawk, vulture, eagle, and falcon species, six nocturnal owl species, and the common raven are the raptor species that have been recorded on the study area. Two species only occur on the study area during migration and two species are winter residents. The golden eagle, red-tailed hawk, American kestrel, great horned owl, and raven are common year-round residents of the study area.

TABLE H-6

RAPTOR SPECIES NOTED ON RBOSP TRACT C-a STUDY AREA DURING 1974-1976

Species	Seasonal Occurrence	Status	Number of Active Nests Located 1975	1976
Turkey vulture	Summer resident	Rare	0	0
Goshawk	Permanent resident	Rare	1	0
Cooper's hawk	Summer resident	Uncommon	2	0
Sharp-shinned hawk	Summer resident	Rare	0	1
Marsh hawk	Permanent resident	Common	3	0
Rough-legged hawk	Winter resident	Uncommon	0	0
Red-tailed hawk	Permanent resident	Common	7	3
Swainson's hawk	Summer resident	Rare	0	0
Golden eagle	Permanent resident	Common	2	2
Bald eagle	Winter resident	Uncommon	0	0
American kestrel	Permanent resident	Common	8	1
Prairie falcon	Permanent resident	Uncommon	0	0
Peregrine falcon	Migrant	Rare	0	0
Merlin	Migrant	Rare	0	0
Great horned owl	Permanent resident	Common	7	1
Screech owl	Permanent resident	Uncommon	0	0
Long-eared owl	Permanent resident	Uncommon	0	0
Short-eared owl	Permanent resident	Common	0	0
Saw-whet owl	Permanent resident	Uncommon	0	0
Pygmy owl	Permanent resident	Uncommon	0	0
Raven	Permanent resident	Common	3	2
			33	10

Definitions of terms used to describe seasonal status are as follow:

Seasonal occurrence

permanent resident: a species present in the study area during all seasons.
summer resident: a species present in the study area throughout the summer, and assumed to nest in the area.
winter resident: a species present in the study area during winter only.
migrant: a species present in the study area only during migration.

Definitions of terms used to describe status follow:

Status

Common: a species noted regularly in its normal habitat at the proper season of the year.
Uncommon: a species of regular occurrence in small numbers, at the proper season of the year, but not likely to be observed on every census.
Rare: a species present in small numbers, and noted only seldomly in proper habitat.

Raptors are distributed throughout the study area. However, the majority of species are associated with the drainages in the lower elevations. The pinyon-juniper woodland and rimrock areas on the slopes adjacent to the drainages provide numerous potential nest and perch sites for many species. The bottomland sagebrush and agriculture bottoms support abundant small mammal populations, the predominant prey base of most raptor species nesting and wintering on the study area.

Thirty-six active raptor nest sites and 21 inactive nests were located on the study area during the two-year raptor nest survey. Nests of nine raptor species were found on the study area and at least eight other species are expected to nest on the area but their nests have not yet been located.

The major factor limiting the wintering and breeding populations of the various raptor species on the study area is probably the availability of food items, particularly deer mice, microtines, lagomorphs, and deer carrion.

(vii) Reptiles and Amphibians

Five reptile species are known to occur in the study area, of which the sagebrush lizard is the most abundant and ubiquitous (percent relative abundance in all sampled areas = 47 percent). The tree lizard, eastern fence lizard, shorthorned lizard (horned toad), and western terrestrial garter snake are less common (percent relative abundances = 42, 9, 1, and 1 percent, respectively). Habitats showing the highest abundance and diversity of reptiles were open, southfacing slopes with ledges and rock piles for basking and shelter and with a few scattered bushes and deadfalls for additional refugia. The limited amount of this habitat in the study area apparently results in a fairly low reptile population density and diversity averaged over the entire area.

Three amphibian species (the chorus frog, Great Basin spadefoot, and tiger salamander) were documented as occurring in the study area at two ponds. The area has very few habitats suitable to breeding populations of amphibians. Abundance and species diversity is low where they do occur.

(viii) Domestic Cattle

Domestic cattle distribution and dispersal in the area are determined by ranchers who own grazing allotments. Cattle are moved to higher elevations in the spring as the snowpack recedes and vegetation becomes green. In the fall, inclement weather conditions force ranchers to move cattle to rangelands at lower elevations.

Three BLM grazing allotments have been set up in the vicinity of Tract C-a. The Reagle and Square S Allotments have been placed under Allotment Management Plans (AMP). The BLM is presently preparing an AMP for the Box Elder allotment. The north-west one-half of Tract C-a is in the Box Elder Allotment and the remaining portion is in the Square S Allotment. Since cattle range freely on and off the tract within the allotments, actual stocking rates in animal unit months (AUMs) have not been calculated for Tract C-a. The BLM estimates that the carrying capacity of Tract C-a is 600 AUMs (personal communication K. Russell, BLM, Meeker, November, 1976).

b. Seasonal Use of the Area

Spring, summer, and fall seasons on Tract C-a are relatively mild, but wintertime temperatures can be quite low, with appreciable amounts of snow. Seasonal use of the area by wildlife is largely dependent upon weather conditions.

(i) Winter

Winter wildlife residents include several species of raptors not commonly found during summer--the bald eagle and the rough legged hawk--as well as several permanent residents - the goshawk, marsh hawk, and redtailed hawk. The sage grouse also occurs at lower elevations during winter. Feral horses are year-round residents. Elk occur at higher elevations to the west of the tract. Some mule deer may remain in the study area during mild winters. Predatory mammals occupy the area year round. Small mammals, while present

during winter, are less active. Sage sparrows and juncos utilize the tract as a winter habitat. Blue grouse reside at higher elevations to the west of the tract.

(ii) Spring

Several songbird and raptor species migrate into the tract vicinity in the spring. Included are: robin, mountain bluebird, red-winged blackbird, vesper sparrow, turkey vulture, Cooper's hawk, Swainson's hawk, and sharp-shinned hawk. Many of the early avifauna spring migrants stay during summer and breed in the area. In the spring mule deer migrate through the study area to summer range at higher elevations. Time of arrival and length of time in the study area depends on weather conditions. Small mammals become more active in the spring, and coyotes and other predatory mammals remain active. Horses in the area begin bearing foals in the spring and continue into summer. Sage grouse move into breeding grounds to the northeast of the tract in spring, and mourning doves migrate into the area. Cattle are moved into the area in late spring after snow has melted.

(iii) Summer

Breeding bird populations reach their peak during the summer. A few mule deer may be found in the study area during summer. Small mammals become very active and predatory mammals continue to utilize the area. Once temperatures are sufficiently high enough reptiles and amphibians in the area become active. Waterfowl move into available habitat near the tract, but do not occupy tract lands proper. Cattle grazing reaches its peak during early summer when range grasses are plentiful. Calving takes place during this season.

(iv) Fall

Major migrations of summer breeding migratory birds take place during the fall with mourning doves, many songbirds and some raptors moving out of the area.

Deer begin moving into the area, headed toward lower winter ranges, and peak numbers may be found on tract during this period. Cattle are moved out of the area as temperatures begin dropping.

c. Threatened and Endangered Species in the Area

Three endangered animal species were identified in the study area during baseline studies. Animal species falling into this category were the peregrine falcon (U.S. and Colorado), the whooping crane (U.S. and Colorado), and the greater sandhill crane (Colorado, if part of a nesting population). Although sighted in the vicinity of the tract, none of these species used the tract proper, nor did the area of use provide critical habitat for these species. The peregrine falcon was found to be a migrant, and was not nesting in the area. The whooping crane and sandhill crane were observed as they stopped over in an area 3 miles northeast of the tract during migrations through the study area.

d. Anticipated Effects of Proposed Development

The Modular Development Phase (MDP) of the Tract C-a development covers the period from September 1977 through December 1981. Activities during this period will include: construction of corridors and access roads on tract to the mine site, dewatering and reinjection wells, and run-of-mine disposal area; clearing of drill pads for dewatering and reinjection holes; clearing of mine and plant sites; and clearing of disposal areas for storage of run-of-mine ore. Total area disturbed during this initial period will include approximately 210 acres. Specific habitat disturbances are shown in Exhibits C and F. A discussion of the anticipated impacts of these disturbances and other associated impacts (e.g., noise, human activity) and planned mitigation activities are presented below.

(i) Construction Impacts

During the MDP, approximately 140 acres will be disturbed during construction of access and service roads, ponds, transmission lines, reinjection system pipelines and clearing for the plant site. Of this total, approximately 50

acres will be reclaimed in 1978 (see Exhibit F). The 45 acres required for the plant site contain pinyon-juniper and upland sagebrush. Small mammals (e.g., deer mice and chipmunks) and songbirds might be adversely affected by the disturbance. Although some small mammals will be destroyed or displaced and some potential nesting habitat for the mountain bluebird and vesper sparrow will be lost, the losses are so small they will not be critical to the animal populations on tract.

Existing access roads will be used whenever possible. Of the 37 acres disturbed for additional corridor (roads and transmission lines) construction, 22 acres will be revegetated according to the RBOSP reclamation plan (Exhibit E) and 15 acres will be permanently lost. This loss in habitat is a small percentage of the 5,100 acres of the site and is not anticipated to affect wildlife populations in the area.

Pipelines for the reinjection system will be buried to avoid impacting deer movements through the area, and the disturbed areas (29 acres) will be completely reclaimed (Exhibit E).

The noise and fugitive dust caused by machinery operation may affect animal relative abundance and distribution in adjacent areas, but this disturbance to animal populations will be short-term impact. Erosion control measures will be employed to minimize any soil loss and thereby prevent adverse impacts caused by surface disturbance.

Construction of retention ponds adjacent to the mine service area will result in the permanent disturbance of approximately 25 acres. These ponds will collect surface runoff to prevent contamination of surface waters. The water in these ponds will be monitored periodically to determine water quality, and fenced, if necessary, to prevent access. Construction of a reservoir along Corral Gulch east of Tract C-a will disturb approximately 40 acres of rabbitbrush, bottomland sagebrush and greasewood vegetation and displace existing fauna (small mammals and songbirds). Corral Gulch will be dammed to collect water from the upper drainage area and used in the water augmentation program (see Exhibit G and Figure C-3 & D-2, Volume II). The reservoir will accumulate

good quality water (see RBOSP Final Environmental Report 1977, Attachment G-2) which will positively benefit domestic animals and wildlife, particularly waterfowl.

Net impact to wildlife caused by construction and associated surface disturbance will be quite small during the MDP because of the limited disturbance and the mitigation measures to be implemented.

(ii) Mining Impacts

During underground mining, overburden and raw shale ore will be excavated to prepare the configuration required for the MIS process and blasting will be necessary to rubblize the oil shale to produce voids for underground retorting. Dewatering will be conducted prior to and during mining operations.

The anticipated concentrations of gaseous emissions (e.g., vented mine air and gases) are below levels that which might affect terrestrial vegetation and fauna. Blasting will produce minor noise levels and seismic shocks (less than one on the Richter scale), but these should not affect animal distribution and abundance on the tract.

Dewatering could cause significant changes in stream flow (Exhibit G). These effects will be monitored. If major springs and seeps in the tract vicinity are impacted, mitigation measures will be initiated and therefore any adverse impacts would be short-term (see Exhibit G).

(iii) Operational Impacts

During the MDP, all shale oil will be produced by underground retorting. By-products of processing include water and low-BTU gas. Ventilation exhaust fans associated with underground operations will produce noise. A thermal oxidizer will be used to burn offgas from retorts during Modular Development.

Burning in the underground retorts should have no direct impact on the terrestrial system. Incineration of the by-products low-BTU gas and water will

reduce air emissions to regulatory levels and as such the effect of air emissions on terrestrial communities should be negligible. Ventilation fan noise is not expected to affect wildlife in the area since it will be reduced to acceptable (MESA) standards. The net impact of mining during the MDP will be low.

(iv) Storage and Transfer Impacts

The storage of fuel, chemicals, explosives, machinery and product oil could result in accidental spills or releases of these substances. Transfer during the MDP will be done primarily by trucks. The water removed from the mine area by dewatering will be transferred to the reinjection locations by pipeline. Surface soil stripped from the disposal area prior to disposal will be stockpiled adjacent to that area (Figure C-3*, and Disposal Impacts below).

These potential impacts will be almost totally mitigated by execution of appropriate control plans, including use of special storage structures, containment of spills by use of dikes, and timely stabilization and reclamation of disturbed areas (See Exhibit E).

(v) Disposal Impacts

Run-of-mine ore, product water, mine seepage water, escape gas, and trash producing during the MDP must be disposed of and are, therefore, potential sources of impact. Gas could escape from the mine area if subsidence occurs. Some of the waste rock and raw shale ore will be used for the construction of haul roads and for improving existing roads; the remainder will be deposited on tract in the run-of-mine ore disposal area.

Disposal of rock and raw shale ore will necessitate the initial clearing of approximately 30 acres. Prior to disposal, all surface soils will be stripped from the area and stockpiled nearby. When the ore disposal pile will no longer be affected by mining activities, the area will be graded, covered with 6 - 12 inches of the surface soils previously stockpiled, and revegetated as described

*See Volume II

in the reclamation plan (Exhibit E). The disposal area will be revegetated with a mixture of grasses, forbs, and shrubs which should provide a variety of forage and browse plant species. The surface soil stockpile may be temporarily revegetated with a quick-growing annual if fugitive dust problems become apparent.

Pinyon-juniper habitat types and upland sagebrush will be the primary vegetation types affected by the disposal of overburden rock and raw shale ore prior to reclamation. This habitat loss will initially reduce the amount of forage, browse and cover available to wildlife (mule deer, small mammals and songbirds). Baseline studies indicated that the range conditions in the study area were fair to poor in pinyon-juniper and fair in sagebrush. However, browse conditions within these habitats were generally considered good (RBOSP Final Environmental Baseline Report 1977, Attachment G-2). The temporary loss of forage and browse should not be significant since the area involved during the MDP is so small.

Since all MIS retort water will be incinerated and mine seepage water will be treated for use or reinjection, no terrestrial impacts should result.

(vi) Manpower Impacts

The construction and operation of MDP mining activities on Tract C-a will require a work force of 250 to 400 persons. It is expected that most personnel will commute from Rangely. In addition, some will commute from Meeker, Rifle, or elsewhere in the general vicinity of the Piceance Creek Basin.

Major potential impacts include an increase in:

- Vehicle-animal collisions
- Hunting (legal and illegal)
- Off-road use of vehicles
- General harassment of wildlife by humans or their pets

The disturbance that would result from 250 to 400 employees commuting and working in a previously remote area is difficult to estimate. Increased accessibilities to remote areas is likely to result in increased recreational use of the tract and adjacent areas. Off-road vehicle use poses the greatest potential for adverse impact on vegetation. The extent of damage to wildlife food and cover and increased soil erosion will be related to the amount of off-road vehicle use.

New road systems will probably increase the amount of hunting (both legal and illegal) and the number of deer-vehicle collisions on and near the tract. Mule deer and raptors are vulnerable to illegal hunting; mule deer road kills could increase substantially.

RBOSP will attempt to mitigate adverse secondary impacts by public relations techniques (e.g., publication of a brochure), enforcement of certain restrictions, instigating certain habitat protection measures, and by use of certain structural methods as follows:

- Public information - A brochure will be developed to inform employees and visitors of rules and regulations governing hunting, fishing, and trapping, wildlife harrassment, and off-road vehicle use. This information will also be posted in conspicuous places as per lease stipulations. The brochure will present general information on important game and wildlife species and their associated habitat.
- Hunting restriction - Hunting and trapping on restricted portions of Tract C-a will be prohibited. RBOSP will consider the conviction of any employee for job-related game violations as grounds for disciplinary action.
- Harrassment restrictions - Unnecessary disturbance of wildlife by RBOSP employees or their pets will be prohibited.
- Off-road vehicle restrictions - All vehicles traveling on Tract C-a will be restricted to designated roads. Construction equipment will be limited to designated roads, construction areas, or disposal areas.
- Habitat protection - Access to newly reseeded, enhanced, or other sensitive areas being restored will be blocked by fences or barriers.

- Structural methods - Deer crossing signs will be installed at appropriate intervals along major roads in the vicinity of the tract and speed limits will be posted on tract.

These mitigation measures should substantially reduce the impacts of increased human presence in the area.

(vii) Subsidence

Underground access corridors and voids resulting from the design of the MIS development will remain after RBOSP mining activities are completed. Subsidence, if not mitigated, could occur as changes in the geologic strata cause sinking or cracking.

RBOSP is currently investigating several alternatives to mitigate and prevent subsidence. These alternatives include alternate mine designs, backfilling the abandoned retorts with a slurry of processed shale, filling cracks or depressions with rock material, or fencing subsidence areas to prevent injury to man or wildlife.

If these mitigative measures are successful, the terrestrial system will not be affected. In the event that subsidence does occur, it could adversely affect the biota if large surface cracks develop. Subsidence will be monitored by RBOSP and appropriate measures will be taken to mitigate subsidence.

(viii) Environmental Actions

During the MDP, mitigation and reclamation plans will be enacted and ecologists will monitor the environment to assess both the impacts of development as well as the results of various mitigation programs. The human activity associated with these monitoring programs will cause negligible impacts. These disturbances will occur for several days only, and no biota will be affected permanently.

Revegetation during the MDP will stabilize the area and provide diverse forage and browse. Although primary succession will be rapid due to the direct planting of species, secondary succession will be more gradual and will require decades. Therefore, the effects will be long-term but should not be considered adverse. The revegetated areas may be initially more suitable to different numbers and kinds of fauna than are current habitats. Introduction of a diverse vegetation could ultimately be beneficial to some wildlife by providing a greater variety of food and cover.

(ix) Other Impacts

Impacts to the aquatic system and to ground and surface water sources are discussed in the NDPES permit application, presented as a part of Exhibit G - Water Information and in Attachments D-1 and G-2.

Additional site specific wildlife information for the proposed mining area (Tract C-a) and a more thorough discussion of potential impacts is available from the Area Oil Shale Supervisor in Grand Junction, Colorado. Sources include:

- RBOSP Progress Reports 1-10 (quarterly) (1974-1977)
- RBOSP Terrestrial Annual Report (1976)
- RBOSP Aquatic Annual Report (1976)
- RBOSP Final Environmental Baseline Report (1977) - Attachment G-2
- RBOSP Revised Detailed Development Plan (1977) - Attachment D-1

LITERATURE CITED

Baker, G. D. and W. T. McKean. 1971. Wildlife management unit 22 (Piceance), Rio Blanco and Garfield Counties, Colorado. Colorado Game, Fish, and Parks Department. 63 pp.

Bartman, R. M. 1974. Piceance deer study-population distribution, game research report. Colorado Division of Wildlife. July: 325-363.

Bartman, R. M. 1975. Piceance deer study-population distribution, game research report. Colorado Division of Wildlife. July: 327-347.

Bartman, R. M. 1976. Piceance deer study-population density and structure, game research report. Colorado Division of Wildlife. July: 434-438.

Colorado Division of Game, Fish, and Parks, 1971. 1970 Colorado Big Game harvest. Colorado Department of Natural Resources, Denver, CO 148 pp.

Colorado Division of Game, Fish, and Parks. 1972. 1971 Colorado Big Game harvest. Colorado Department of Natural Resources. Denver, CO 158pp.

Colorado Division of Wildlife. 1973. 1972 Colorado Big Game harvest. Colorado Department of Natural Resources. Denver, CO 204 pp.

Colorado Division of Wildlife. 1974. 1973 Colorado Big Game harvest. Colorado Department of Natural Resources. Denver, CO 229 pp.

Colorado Division of Wildlife. 1975. 1974 Colorado Big Game harvest. Colorado Department of Natural Resources. Denver, CO 173 pp.

Colorado Division of Wildlife. 1976. 1975 Colorado Big Game harvest. Colorado Department of Natural Resources. Denver, CO 198 pp.

RBOSP. 1974-1977. Progress Reports 1-10 (quarterly). Gulf-Standard. Denver, CO.

RBOSP. 1976. Aquatic Studies Annual Report. Gulf-Standard. Denver, Co.

RBOSP. 1976. Terrestrial Studies Annual Report. Gulf-Standard. Denver, Co.

RBOSP. 1977. Final Environmental Baseline Report. Gulf-Standard. Denver, Co. 703 pp. Attachment G-2

RBOSP. 1977. Revised Detailed Development Plan. Gulf-Standard. Denver, Co. 3 Vols. Attachment D-1

ATTACHMENT H-1

AVIFAUNA SPECIES IDENTIFIED FROM THE TRACT C-a
STUDY AREA DURING TWO YEARS OF BASELINE STUDIES
OCTOBER 1974 - SEPTEMBER 1976

ORDER FAMILY Species	Common Name
CICONIFORMES	
ARDEIDAE	
Ardea herodias	Great blue heron
CICONIIDAE	
Plegadis chihi	White-faced ibis
ANSERIFORMES	
ANATIDAE	
Anas platyrhynohos	Mallard
Anas strepera	Gadwall
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas cyanoptera	Cinnamon teal
Aythya americana	Redhead
FALCONIFORMES	
CATHARTIDAE	
Cathartes aura	Turkey vulture
ACCIPITRIDAE	
Accipiter gentilis	Goshawk
Accipiter striatus	Sharp shinned hawk
Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Buteo lagopus	Rough-legged hawk
Aquila chrysaetos	Golden eagle
Haljaeetus leuocepahlus	Bald eagle

ORDER / FAMILY / Species	Common Name
Circus cyaneus	Marsh hawk
FALCONIDAE	
Falco mexicanus	Prairie falcon
Falco peregrinus	Peregrine falcon
Falco columbarius	Merlin
Falco sparverius	American kestrel
GALLIFORMES	
TETRAONIDAE	
Dendragapus obscurus	Blue grouse
Centrocercus urpohasianus	Sage grouse
GRUIFORMES	
GRUIDAE	
Grus americana	Whooping crane
Grus canadensis tabida	Greater sandhill crane
RALLIDAE	
Rallus limicola	Virginia rail
Porzana carolina	Sora
Fulica americana	American coot
CHARADRIIFORMES	
CHARADIIDAE	
Charadrius semipalamatus	Semipalmated plover
Charadrius vociferus	Killdeer
SCOLOPACIDAE	
Capella gallinago	Common snipe
Actitis macularia	Spotted sandpiper
Tringa solitoria	Solitary sandpiper
Tringa flavipes	Lesser yellowlegs

ATTACHMENT H-1

AVIFAUNA SPECIES IDENTIFIED FROM THE TRACT C-a
STUDY AREA DURING TWO YEARS OF BASELINE STUDIES
OCTOBER 1974 - SEPTEMBER 1976

ORDER / FAMILY / Species	Common Name
CICONIFORMES	
ARDEIDAE	
Ardea herodias	Great blue heron
CICONIIDAE	
Plegadis chihi	White-faced ibis
ANSERIFORMES	
ANATIDAE	
Anas platyrhynohos	Mallard
Anas strepera	Gadwall
Anas clypeata	Northern shoveler
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas cyanoptera	Cinnamon teal
Aythya americana	Redhead
FALCONIFORMES	
CATHARTIDAE	
Cathartes aura	Turkey vulture
ACCIPITRIDAE	
Accipiter gentilis	Goshawk
Accipiter striatus	Sharp shinned hawk
Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Buteo lagopus	Rough-legged hawk
Aquila chrysaetos	Golden eagle
Haliaeetus leuocepahlus	Bald eagle

ORDER FAMILY Species	Common Name
Circus cyaneus	Marsh hawk
FALCONIDAE	
Falco mexicanus	Prairie falcon
Falco peregrinus	Peregrine falcon
Falco columbarius	Merlin
Falco sparverius	American kestrel
GALLIFORMES	
TETRAONIDAE	
Dendragapus obscurus	Blue grouse
Centrocercus urpohasianus	Sage grouse
GRUIFORMES	
GRUIDAE	
Grus americana	Whooping crane
Grus canadensis tabida	Greater sandhill crane
RALLIDAE	
Rallus limicola	Virginia rail
Porzana carolina	Sora
Fulica americana	American coot
CHARADRIIFORMES	
CHARADIIDAE	
Charadrius semipalamatus	Semipalmated plover
Charadrius vociferus	Killdeer
SCOLOPACIDAE	
Capella gallinago	Common snipe
Actitis macularia	Spotted sandpiper
Tringa solitoria	Solitary sandpiper
Tringa flavipes	Lesser yellowlegs

ORDER FAMILY Species	Common Name
Numenius americanus	Long-billed curlew
RECURVIROSTRIDAE	
Recurvirostra americana	American avocet
PHALAROPODIDAE	
Steganopus tricolor	Wilson's phalarope
COLUMBIFORMES	
COLUMBIDAE	
Zenaida macroura	Mourning dove
STRIGIFORMES	
STRIGIDAE	
Otus asio	Screech owl
Bubo virginianus	Great horned owl
Asio otus	Long-eared owl
Asio flammeus	Short-eared owl
Aegolius acadicus	Saw-whet owl
Glaucidium gnoma	Pygmy owl
CAPRIMULGIFORMES	
CAPRIMULGIDAE	
Phalaenoptilus nuttallii	Poor-will
Chordeiles minor	Common night hawk
APODIFORMES	
APODIDAE	
Aeronautes saxatalis	White-throated swift
TROCHILIDAE	
Selasphorus platycercus	Broad-tailed hummingbird
PICIFORMES	
PICIDAE	
Colaptes auratus	Common flicker
Picoides villosus	Hairy woodpecker

ORDER FAMILY Species	Common Name
Picoides pubescens	Downy woodpecker
PASSERIFORMES	
TYRANNIDAE	
Sayornis sava	Say's phoebe
Empidonax hammondii	Hammond's flycatcher
Empidonax wrightii	Gray flycatcher
Contopus sordidulus	Western wood pewee
Nuttallornis borealis	Olive-sided flycatcher
ALAUDIDAE	
Eremphila alpestris	Horned lark
HIRUNDINIDAE	
Tachycineta thalassina	Violet-green swallow
Iridoprocne bicolor	Tree swallow
Stelgidopteryx ruficollis	Rough-winged swallow
Hirundo rustica	Barn swallow
Petrochelidon pyrrhonota	Cliff swallow
CORVIDAE	
Cyanocitta stelleri	Steller's jay
Amphelocoma coerulescens	Scrub jay
Pica pica	Black-billed magpie
Corvus corax	Common raven
Corvus brachyrhynchos	Common crow
Gymnorhinus cyanocephalus	Pinyon jay
VORVIDAE	
Nucifraga columbiana	Clark's nutcracker
PARIDAE	
Parus atricapillus	Black-capped chickadee
Parus gambeli	Mountain chickadee

ORDER FAMILY Species	Common Name
Parus inornatus	Plain titmouse
Psaltriparus minimus	Bushtit
SITTIDAE	
Sitta carolinensis	White-breasted nuthatch
Sitta canadensis	Red-breasted nuthatch
Sitta pygmaea	Pygmy nuthatch
CERTHIIDAE	
Certhia familiaris	Brown creeper
TROGLODYTIDAE	
Troglodytes aedon	House wren
Salpinctes obsoletus	Rock wren
MIMIDAE	
Oreoscoptes montanus	Sage thrasher
TURDIDAE	
Turdus migratorius	Robin
Catharus guttata	Hermit thrush
Sialia currocoides	Mountain bluebird
Myadestes townsendii	Townsend's solitaire
SYLVIIDAE	
Polioptila caerulea	Blue-gray gnatcatcher
Regulus calendula	Ruby-crowned kinglet
MOTACILLIDAE	
Anthus spinoletta	Water pipit
BOMBYCILLIDAE	
Bombycilla garrulus	Bohemian waxwing
Bombycilla cedrorum	Cedar waxwing
LANIIDAE	
Lanius excubitor	Northern shrike

ORDER FAMILY Species	Common Name
Lanius ludovicianus	Loggerhead shrike
STURNIDAE	
Sturnus vulgaris	Starling
VIREONIDAE	
Vireo vicinior	Gray vireo
Vireo solitarius	Solitary vireo
Vireo olivaceus	Red-eyed vireo
Vireo gilvus	Warbling vireo
PARULIDAE	
Vermivora peregrina	Tennessee warbler
Vermivora celata	Orange-crowned warbler
Vermivora virginiae	Virginia's warbler
Dendroica petechia	Yellow warbler
Dendroica coronata	Yellow-rumped warbler
Dendroica nigrescens	Black-throated gray warbler
Oporornis tolmiei	MacGillivray's warbler
PLOCEIDAE	
Passer domesticus	House sparrow
ICTERIDAE	
Dolichonyx oryzivorus	Bobolink
Sturnella neglecta	Western meadowlark
Angelaius phoeniceus	Red-winged blackbird
Euphagus cyanocephalus	Brewer's blackbird
Molothrus ater	Brown-headed cowbird
Icterus galbula	Northern oriole
THRAUPIDAE	
Piranga ludoviciana	Western tanager

ORDER / FAMILY / Species	Common Name
FRINGILLIDAE	
Pheucticus melanocephalus	Black-headed grosbeak
Hesperiophona vespertina	Evening grosbeak
Carpodacus cassinii	Cassin's finch
Carpodacus mexicanus	House finch
Pinicola enucleator	Pine grosbeak
Leucosticte astrata	Black-rosy finch
Leucosticte australis	Brown-capped rosy finch
Spinus pinus	Pine siskin
Loxia curvirostra	Red crossbill
Chlorura chlorura	Green-tailed towhee
Pipilo erythrophthalmus	Rufous-sided towhee
Calamospiza melanocorys	Lark bunting
Ammodramus savannarum	Grasshopper sparrow
Pooecetes gramineus	Vesper sparrow
Chondestes grammacus	Lark sparrow
Amphispiza belli	Sage sparrow
Junco hyemalis	Dark-eyed junco
Junco caniceps	Gray-headed junco
Spizella arborea	Tree Sparrow
Spizella passerina	Chipping sparrow
Spizella breweri	Brewer's sparrow
Zonotrichia leurophyrys	White-crowned sparrow
Zonotrichia atricapilla	Golden-crowned sparrow
Passerella iliaca	Fox sparrow
Melospiza melodia	Song sparrow
Calcarius mccownii	McCown's longspur
Calcarius ornatus	Chestnut-collared longspur

ORDER FAMILY Species	Common Name
Plectrophenox nivalis	Snow bunting

1/ The following authorities are used for bird nomenclature:

American Ornithologists' Union, 1957. Checklist of North American Birds, Fifth edition. Port City Press, Baltimore, Maryland. 691 pages.

American Ornithologists's Union, 1976. Thirty-third supplement to the American Ornithologist's Union checklist of North American Birds (Fifth edition, 1957). Auk 93:875-879.

ATTACHMENT H-2

MAMMAL SPECIES IDENTIFIED FROM THE TRACT C-a STUDY AREA DURING TWO YEARS OF BASELINE STUDIES, OCTOBER 1974 - SEPTEMBER 1976

FAMILY Species	Common Name
SORICIDAE (Shrews)	
Sorex cinereus	Masked shrew
Sorex merriami	Merriam's shrew
Sorex vagrans	Wandering shrew
VESPERTILIONIDAE (Bats)	
Myotis californicus	California myotis
Myotis evotus	Long-eared myotis
Myotis leibii	Small-footed myotis
Myotis volans	Long-legged myotis
Eptesicus fuscus	Big brown bat
Lasiurus cinereus	Hoary bat
Lasionycteris noctivagans	Silver-haired bat
LEPORIDAE (Hares and rabbits)	
Sylvilagus nuttallii	Nuttall's cottontail
Sylvilagus sp.	Cottontail
Lepus californicus	Black-tailed jackrabbit
Lepus townsendii	White-tailed jackrabbit
SCIURIDAE (Squirrels, ground squirrels, chipmunks)	
Eutamias minimus	Least chipmunk
Eutamias quadrivittatus	Colorado Chipmunk
Spermophilus lateralis	Golden-mantled ground Squirrel

FAMILY Species	Common Name
Spermophilus tridecemlineatus	Thirteen-lined ground squirrel
Tamiasciurus hudsonicus	Red squirrel
GEOMYIDAE (Pocket gophers)	
Thomomys talpoides	Northern pocket gopher
HETEROMYIDAE (Pocket mice, kangaroo mice and kangaroo rats)	
Perognathus apache	Apache pocket mouse
CRICETIDAE (New World mice and rats)	
Peromyscus maniculatus	Deer mouse
Peromyscus truei	Pinon mouse
Neotoma cinerea	Bushy-tailed woodrat
Clethrionomys gapperi	Gapper's red-backed vole
Microtus longicaudus	Long-tailed vole
Microtus montanus	Montane vole
Lagurus curtatus	Sagebrush vole
ERETHIZONTIDAE (Porcupines)	
Erethizon dorsatum	Porcupine
CANIDAE (Coyote, wolves and foxes)	
Canis latrans	Coyote
MUSTELIDAE (Mustelids, weasels, skunks)	
Mustela erminea	Ermine
Mustela frenata	Long-tailed weasel
Taxidea taxus	Badger

FAMILY Species	Common Name
FELIDAE (Cats)	
Lynx rufus	Bobcat
EQUIDAE (Horses)	
Equus caballus	Feral horse
CERVIDAE (Elk and Deer)	
Cervus canadensis	Elk 3/
Odocoileus hemionus	Mule deer 3/

1/ The following authority is used for small mammal nomenclature:

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Ronald Press Company, New York. 1162 pages.

2/ The following authority is used for wild horse nomenclature:

Blair, W.F., A.P. Blair, P. Broadkorb, F.R. Cagle and G.A. Moore. 1968. Vertebrates of the United States, second edition. McGraw-Hill Book Company. New York. 616 pages.

3/ The following authority is used for large mammal (except wild horse) nomenclature:

Lechleitner, R.R. 1969. Wild mammals of Colorado. Pruette Publishing Company, Boulder, Colorado. 254 pages.

ATTACHMENT H-3

SPECIES OF AMPHIBIANS AND REPTILES ENCOUNTERED
IN THE VICINITY OF TRACT C-a
DURING TWO YEARS OF BASELINE STUDIES,
OCTOBER 1974 - SEPTEMBER 1976 [1]

CLASS FAMILY Species	Common Name
AMPHIBIA	
AMBYSTOMIDAE	
Ambystoma tigrinum	Tiger salamander
PELOBATIDAE	
Scaphiopus intermontanus	Great Basin spadefoot
HYLIDAE	
Pseudacris triseriata	Chorus frog
REPITILIA	
IGUANIDAE	
Sceloporus undulatus	Eastern fence lizard
Sceloporus graciosus	Sagebrush lizard
Urosaurus ornatus	Tree lizard
Phrynosoma douglassi	Short-horned lizard
COLUBRIDAE	
Thamnophis elegans	Western terrestrial garter snake

[1] Stebbins (1966) was used for amphibian and reptile nomenclature.

RIO BLANCO OIL SHALE PROJECT
DAYTON COMMONS 9725 E. HAMPDEN AVENUE
DENVER, COLORADO 80231 303-751-2030

September 1, 1977

Mr. Tom Henry
Environmental Specialist
Division of Wildlife
711 Independence Street
Grand Junction, CO 81501

Dear Mr. Henry:

The Rio Blanco Oil Shale Project (RBOSP) is currently engaged in completing an "Application for Mining and Reclamation Permit" pursuant to C.R.S. 1973, 34-32-101, for the proposed Modular Development Phase (1977-1981) of oil shale development on Tract C-a in Rio Blanco County, Colorado. Requisite to completion of this form, we must provide Exhibit H - Wildlife Information, describing significant wildlife resources in the area and the general effects of Modular Development Phase mining activities on these wildlife.

As you know, RBOSP has already submitted to the Area Oil Shale Supervisor a great deal of environmental data, including annual and final reports, ten quarterly progress reports, and the Revised DDP. These reports include results of two years of baseline environmental studies, and the revised DDP includes an assessment of anticipated impacts for the Modular Development Phase. I believe you have copies of, or access to, these documents.

We are currently summarizing information from these reports for submission with the permit application as Exhibit H. In line with requirements to receive Division of Wildlife comments on our wildlife information, we would appreciate a "Wildlife Statement for Mine Permit Application" from your office. Should you need additional information from us to complete this form, please do not hesitate to ask.

Yours very truly,

Sam H. Miller
Manager Environmental Affairs

:pf

cc: T. M. Ivory - NUS Corp.
J. B. Miller
R. M. Lieber

STATE OF COLORADO
Richard D. Lamm, Governor
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
Jack R. Grieb, Director
6060 Broadway
Denver, Colorado 80216 (825-1192)
711 Independent Avenue
Grand Junction, Colorado 81501

September 8, 1977

Mr. Sam H. Miller
Manager Environmental Affairs
Rio Blanco Oil Shale Project
Dayton Commons 9725 E. Hampden Avenue
Denver, Colorado 80231

Dear Mr. Miller:

Here is the Wildlife Statement for the mine permit application you requested. I feel that the baseline data that has been gathered is more than adequate for your application and is more information than we would provide.

I hope that the mined land reclamation board is aware of all of the reports and baseline data that has been gathered and that is available.

This information should be adequate to complete your application as far as the wildlife comments are concerned. If you need additional information or comments, please feel free to contact me.

Sincerely,

Thomas K. Henry, Jr.

Thomas K. Henry, Jr.
Wildlife Biologist

TKH:jg

cc: R. Taliaferro
R. Krager
File

DEPARTMENT OF NATURAL RESOURCES, Harris Sherman, Executive Director • WILDLIFE COMMISSION, Vernon C. Williams, Chairman
Thomas Farley, Vice Chairman • Sam Caudill, Secretary • Jean K. Tool, Member • Roger Clark, Member
Jay K. Childress, Member • Dean Hull, Member • Dean Suttle, Member

WILDLIFE STATEMENT FOR MINE PERMIT APPLICATION

1. **Mine Company**

   Rio Blanco Oil Shale Project
   9725 E. Hampden Avenue
   Denver, Colorado 80231

2. **Mine Type and Location, County, T, R, S.**

   In situ oil shale, Tract C-a

3. **Duration of Operation**

   30 plus years

4. **Total Area Disturbed - How many acres at a time.**

   This information is in the DDP (Revised).

5. **Wildlife Species List**

   See baseline data reports on the revised Detail Development Plan. These reports are as complete as possible.

6. **Endangered Species Impacted**

   Again refer to DDP and other published reports.

7. **Assessment of Mining Impact on Wildlife**

   This prototype mine will give us a great deal of information in the future to give an adequate assessment on mining impacts on wildlife.

8. **Proposed Mitigation Measures Including Reclamation for Wildlife Habitat**

   There are many recommendations in our correspondence with both (RBOSP) and the oil shale supervisor's office. Also CSU and others are working on mitigation and oil shale.

Prepared by: Thomas K. Henry **Title:** Wildlife Biologist

Date: 9-8-77

Use additional sheets as necessary for any of the above.

EXHIBIT
I

EXHIBIT I

SOILS INFORMATION

EXHIBIT I - SOILS INFORMATION

An extensive soil study was conducted on Tract C-a and adjacent areas during 1976. This study provided information regarding the soil types and their distribution in the study area, the chemical and physical traits of these soils, and suitability of topsoil as a plant growth medium. The results of this study are presented in detail in the RBOSP Final Environmental Baseline Report (1977) Attachment G-2.

a. Soil Types and Distribution

Nine soil types consisting of six unique soil series and three soil complexes were identified within the study area. The areal distribtuion of each soil type in the study area is presented in Figure I-1. A detailed map (1" = 500') of the soil types affected by mining activities is presented in Exhibit C (Figure C-5)*Volume II.

Over 70 percent of surface soils (upper 1.5m) of tract was dominated by two soil types, the Rentsac series (46 percent), and the Rentsac-Piceance complex (27 percent). The major portion of the remaining area consisted of Rock Outcrop-Torriorthent complex (11 percent), the Glendive series(9 percent) and the Redcreek-Rentsac complex (6 percent).

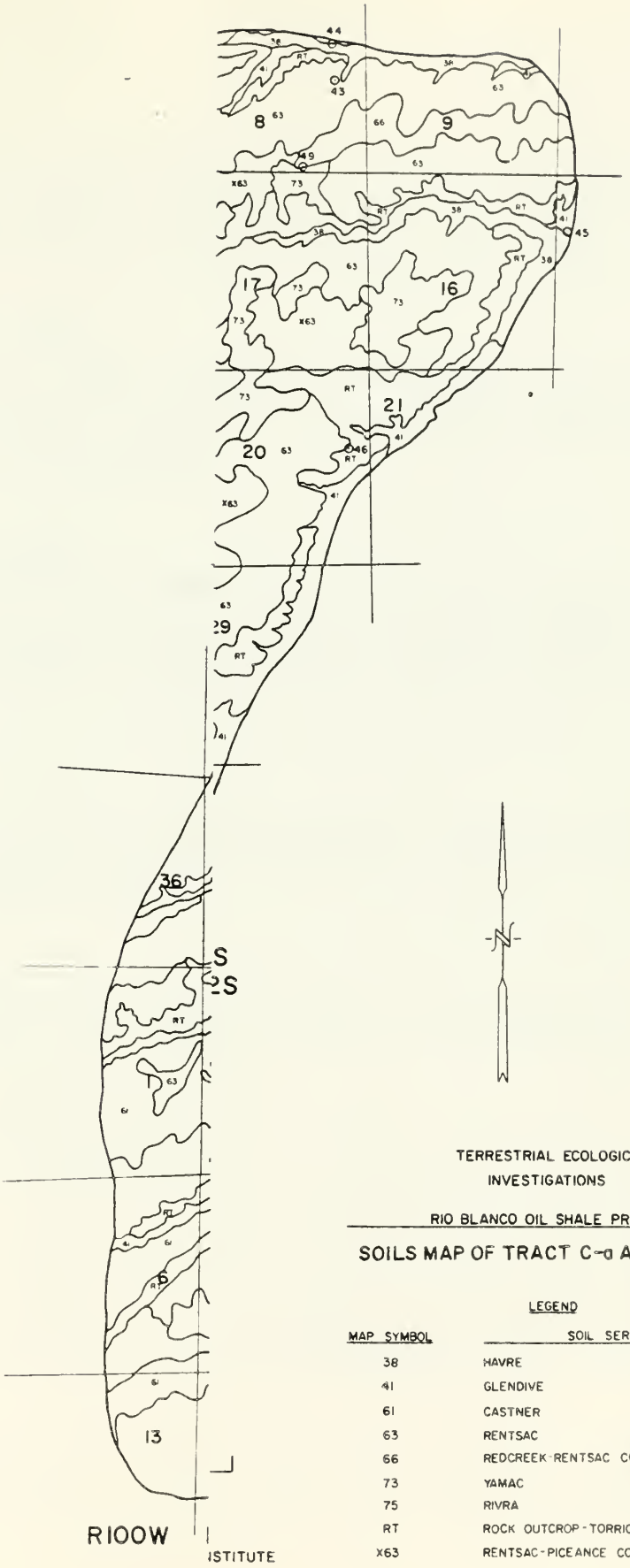
The following is a discussion of the mapping units shown in Figure I-1.

Havre Series (38)
Small areas of the Glendive series may be included in this mapping unit.

Glendive Series (61)
In areas that are nearly level, small areas of the Havre series may be found. In steeper areas near the upstream boundary of the Glendive series small areas ofthe Rivra series may be included.

Castner Series (61)
Small inclusions of the Rentsac series and of the Torriorthent series may be found within the Castner series.

* See Volume II



TERRESTRIAL ECOLOGICAL
INVESTIGATIONS

RIO BLANCO OIL SHALE PROJECT

SOILS MAP OF TRACT C-a AND VICINITY

LEGEND

MAP SYMBOL	SOIL SERIES
38	HAVRE
41	GLENDIVE
61	CASTNER
63	RENTSAC
66	REDCREEK-RENTSAC COMPLEX
73	YAMAC
75	RIVRA
RT	ROCK OUTCROP-TORRIORTHENT COMPLEX
X63	RENTSAC-PICEANCE COMPLEX

FIGURE I-1

Rentsac Series (63)

In areas where the slope exceeds approximately 35 percent, small areas of the Torriorthent series may be found. Where the slope is less than 15 percent, small areas of the Redcreek series may be included in this mapping unit.

Rentsac-Piceance Complex (X63)

The Rentsac series makes up about 50 percent of this mapping unit and the Piceance series comprises approximately 40 percent. The remaining 10 percent consists of the Rock Outcrop-Torriorthent complex.

Redcreek-Rentsac Complex (66)

The Redcreek series makes up approximately 50 percent of this mapping unit, the Rentsac series makes up about 40 percent, and the remaining 10 percent consists of the Rock Outcrop-Torriorthent complex, the Yamac series, and the Piceance series.

Yamac Series (73)

Small areas of the Piceance series and of the Rentsac series are found within the boundaries of the Yamac series.

Rivra Series (75)

Small areas of the Glendive series may be included in this mapping unit, especially where the slope is less than 5 percent.

Rock Outcrop-Torriorthent Complex (RT)

Approximately 45 percent of this mapping unit consists of rock outcrops occurring as horizontal sandstone cliffs and as platy shale outcrops. These outcrops are generally found along the major canyons dissecting the study area. Vegetation is very sparse on these strongly sloping outcrops. An unnamed Torriorthent occupies about 40 percent of the area and the remainder consists of the Rentsac series.

The soil profile descriptions of the five major soil series are presented in Attachment I-1.

b. Chemical and Physical Characteristics of Soils in the Study Area

Chemical and physical properties of surface soils of Tract C-a and vicinity (Table I-1) were typical of semi-arid regions in the western United States. These soils were composed of a mixture of sandy silt, sand clay, and gravelly clay. Surface soils were slightly basic (average pH of 8.3 and 8.4). Organic matter content was moderate to low in surface soils (3.1 percent) with maximum levels of organic matter at the soil surface. Cation exchange capacity for soils of this semi-arid region was normal (CEC = 34.2). Surface soils were deficient in nitrogen and phosphorus. Only traces of potentially toxic elements occurred in the surface soils of Tract C-a and vicinity. Trace element concentrations were within ranges considered normal for soils and nontoxic to plants and animals. Selenium is the only exception, with three sites outside the boundaries of the tract containing more plant-available selenium than is normally found in soils of semi-arid regions. Most soils of the study area had a coarse to medium texture and had the potential to retain sufficient water and nutrients for normal plant growth. The chemical and physical soil traits of the major soil series are presented in Table I-2.

The soil series was used as the basis for determining and mapping the depth of topsoil in addition to the depth to rock.

Topsoil depth is quite variable and therefore, only average values (0-150-cm) are presented in the map of top soil depths (Figure I-2). A detailed map (1" = 500') of the topsoil depth occurring in areas affected by mining activities is presented in Exhibit C (Figure C-6). A discussion of the depth of each soil type is included in the soil series descriptions presented in Attachment I-1.

c. Suitability of Topsoil as a Plant Growth Medium

Soil properties most frequently limiting the use of soil for topsoil are rock, salinity and excessive sodium (sodic). Material with an electrical conductivity of 8.0 mmhos/cm or greater were considered unsuitable for use as topsoil. Salinity is especially restrictive during plant germination and early growth. If such material were used as topsoil, it is probable that eventually plants would become established (as evidenced by undisturbed

* See Volume II

TABLE I-1

CHEMICAL AND PHYSICAL TRAITS OF SOILS OF THE STUDY AREA(1)

Parameter	pH in Water	pH in 0.01M $CaCl_2$	Soluble Salt Electrical Conductivity mmhos/cm (2)	Soluble Salt Electrical Conductivity mmhos/cm (3)	Sodium Water Soluble	Sodium NH_4 Acetate Soluble	Cation Exchange Capacity	Exchangeable Sodium Percentage
					(milliequivalents/100 g)			
Mean	8.4	7.8	0.89	3.5	1.02	2.87	37.0	5.0
Range	6.9-9.9	6.1-9.2	0.10-11.50	0.5-59.0	0.02-19.48	0.03-30.1	10.3-89.2	0.01-53.46
Standard Deviation	0.5	0.4	1.5	6.5	2.0	3.7	13.3	9.3

Parameter	Ammonium ppm	Nitrate ppm	Phosphorus $NaHCO_3$ Extractable ppm	Potassium Available ppm	Water Soluble					DTPA Extractable			
					Magnesium ppm	Calcium ppm	Potassium ppm	Sulfate ppm	Boron ppm	Copper ppm	Manganese ppm	Iron ppm	Zinc ppm
Mean	9.3	6.3	12.7	385.1	16.2	59.8	12.2	323.2	0.6	1.8	33.7	104.4	1.5
Range	0.4-35.2	<0.1-420.0	1.0-155.0	80.0-2540.0	0.4-319.7	3.6-679.0	0.9-190.0	5.0-6200.0	0.5-1.9	0.5-13.6	6-214	12-448	0.4-9.0
Standard Deviation	5.4	29.1	14.9	338.2	36.5	101.2	18.1	664.2	0.2		21.5	64.0	0.9

Parameter	Molybdenum Anion Exchangeable ppm	Organic Matter %	Gypsum Requirement MEQ/100 g	Lime Requirement lb $CaCO_3$/ acre	Total							
					Phosphorus ppm	Arsenic ppm	Cadmium ppm	Chloride ppm	Chromium ppm	Cobalt ppm	Fluoride ppm	Mercury ppb
Mean	0.3	2.9	0.4	0	541.8	8.4	<0.5	910.0	44.4	8.0	510.0	18.8
Range	0.1-2.4	0.1-21.8	0.2-6.0	0	95-1549	5-40	<0.5-0.5	200-2500	20-80	1-35	160-1150	10-110
Standard Deviation	0.2	2.5	0.6	0	198.5	5.7	<0.01	330.8	9.8	2.6	194.0	12.0

Parameter	Total		Selenium Available ppb	NH_4 Acetate Extractable		Background Radioactivity				
	Antimony ppm	Vanadium ppm		Nickel ppm	Lead ppm	Uranium ppm	Equivalent Uranium ppm	Equivalent Thorium ppm	Potassium Radioactivity %	Radium-226 Picocuries/ g
Mean	1.0	59.1	56.4	0.9	1.4	2.2	2.7	10.5	2.	0.9
Range	1-3	20-110	10-2600	0.3-2.4	0.6-4.0	2-5	1-8	2-30	n.r.	0.5-2.5
Standard Deviation	0.2	13.8	253.3	0.3	0.5	0.6	1.1	3.6		0.4

Parameter	Water-Holding Capacity, % (Dry Sample Wt. Basis)		Particle-Size Analysis, Wt. %			Textural Class
	1/3 Bar Suction	15 Bar Suction	Sand -2.0 +0.05 mm	Silt -0.05 +0.002 mm	Clay -0.002 mm	
Mean	25.7	12.6	39.1	47.0	13.9	Loam
Range	11.5-50.9	5.4-26.3	3.0-85.5	12.5-77.0	2.0-34.0	
Standard Deviation	7.3	3.5	17.4	13.8	6.3	

(1) n= 312.
(2) Sample to extract ratio: 1 to 2.
(3) Conductivity for a saturation extract based on 1 to 2 ratio conductivity data and the 1/3 bar water-holding capacity.

TABLE I-2

CHEMICAL AND PHYSICAL TRAITS OF THE MAJOR SOIL SERIES[1]

Soil Series	pH in Water	pH in 0.01M $CaCl_2$	Soluble Salt Electrical Conductivity mmhos/cm (2)	Soluble Salt Electrical Conductivity mmhos/cm (3)	Sodium Water Soluble (milliequivalents/100 g)	Sodium NH_4 Acetate Soluble (milliequivalents/100 g)	Cation Exchange Capacity (milliequivalents/100 g)	Exchangeable Sodium Percentage
Glendive	8.5	7.9	0.82	3.4	0.76	2.33	29.4	5.2
Redcreek	8.2	7.6	0.55	2.4	0.45	1.51	39.3	2.7
Yamac	8.3	7.5	0.39	1.6	0.42	1.59	42.3	2.9
Rentsac	8.2	7.6	0.42	1.6	0.33	1.50	42.2	2.8
Torriorthent	8.3	8.1	2.21	8.8	3.17	5.46	25.3	9.1
Piceance	8.4	7.8	0.31	1.3	0.39	1.35	40.7	2.4

Soil Series	Ammonium ppm	Nitrate ppm	Phosphorus $NaHCO_3$ Extractable ppm	Potassium Available ppm	Water Soluble: Magnesium ppm	Water Soluble: Calcium ppm	Water Soluble: Potassium ppm	Water Soluble: Sulfate ppm	Water Soluble: Boron ppm	DTPA Extractable: Copper ppm	DTPA Extractable: Manganese ppm	DTPA Extractable: Iron ppm	DTPA Extractable: Zinc ppm
Glendive	10.1	4.8	23.0	646.1	15.8	65.1	26.8	295.7	0.7	1.6	30.7	95.8	1.7
Redcreek	9.8	1.8	23.1	348.3	12.4	48.6	10.6	190.7	0.7	1.2	49.0	115.0	1.5
Yamac	9.2	1.8	12.3	489.4	7.7	33.6	7.6	184.2	0.5	1.4	34.9	97.8	1.1
Rentsac	9.5	2.3	11.3	264.0	6.3	41.4	5.5	133.5	0.6	1.7	37.2	104.0	1.4
Torriorthent	11.1	10.3	7.3	151.1	32.0	225.4	8.8	1246.0	0.7	3.1	20.8	76.3	1.2
Piceance	10.2	1.5	8.7	412.7	7.4	41.5	7.8	245.9	0.6	1.8	44.3	83.3	1.4

Soil Series	Molybdenum Anion Exchangeable ppm	Organic Matter %	Gypsum Requirement MEQ/100 g	Lime Requirement lb $CaCO_3$/ acre	Total: Phosphorus ppm	Total: Arsenic ppm	Total: Cadmium ppm	Total: Chloride ppm	Total: Chromium ppm	Total: Cobalt ppm	Total: Fluoride ppm	Total: Mercury ppb
Glendive	0.4	3.4	0.3	0	533.1	7.7	0.5	935.7	47.3	7.5	585.7	18.8
Redcreek	0.3	3.5	0.3	0	526.0	5.7	0.5	836.7	45.0	8.1	436.8	16.0
Yamac	0.2	2.3	0.3	0	711.2	6.3	0.5	700.0	48.4	9.4	368.8	12.5
Rentsac	0.3	4.1	0.3	0	503.6	9.1	0.5	874.6	42.9	7.7	478.8	23.7
Torriorthent	0.4	2.0	0.4	0	455.1	14.3	0.5	1128.6	36.4	7.2	644.3	33.9
Piceance	0.3	2.7	0.2	0	572.9	8.1	0.5	769.2	43.1	8.2	433.1	15.1

Soil Series	Total: Antimony ppm	Total: Vanadium ppm	Selenium Available ppb	NH_4 Acetate Extractable: Nickel ppm	NH_4 Acetate Extractable: Lead ppm	Background Radioactivity: Uranium ppm	Equivalent Uranium ppm	Equivalent Thorium ppm	Potassium Radioactivity %	Radium-226 Picocuries/ g
Glendive	1.0	58.9	29.3	0.8	1.5	2.1	2.6	9.5	2.4	0.9
Redcreek	1.0	52.8	12.0	0.9	1.5	2.3	2.2	12.6	2.7	0.8
Yamac	1.0	61.6	11.3	0.8	1.1	2.1	2.3	11.5	2.7	0.8
Rentsac	1.1	56.8	18.0	0.8	1.5	2.2	2.9	9.6	2.4	1.1
Torriorthent	1.0	53.9	70.7	1.4	2.2	2.2	2.6	8.0	2.4	0.8
Piceance	1.0	62.7	13.9	0.9	1.3	2.1	3.1	11.3	2.5	1.0

Soil Series	Bulk Density g/cm^3 (4)	Water-Holding Capacity, (Dry Sample Wt. Basis): 1/3 Bar Suction	Water-Holding Capacity, (Dry Sample Wt. Basis): 15 Bar Suction	Particle-Size Analysis, Wt.: Sand -2.0- 0.05 mm	Silt -0.05 - 0.002 mm	Clay -0.002 mm	Textural Class
Glendive	1.03	23.9	11.8	42.0	47.2	10.8	Loam
Redcreek	1.28	22.1	12.1	47.6	40.4	12.0	Loam
Yamac	1.27	23.9	11.1	38.8	45.5	15.8	Loam
Rentsac	1.25	28.0	14.1	37.1	48.7	14.2	Loam
Torriorthent	0.93	25.1	11.1	30.9	58.5	10.8	Silt loam
Piceance	1.25	25.2	12.6	31.9	51.6	16.5	Silt loam

(1) Individual parameters express the mean value of the 0 to 10 plus the 10 to 50 cm depths.
(2) Sample to extract ratio: 1 to 2.
(3) Conductivity for a saturation extract based on 1 to 2 ratio conductivity data and the 1/3 bar water-holding capacity.
(4) Weighted average of bulk density of upper 50 cm of soil profile.

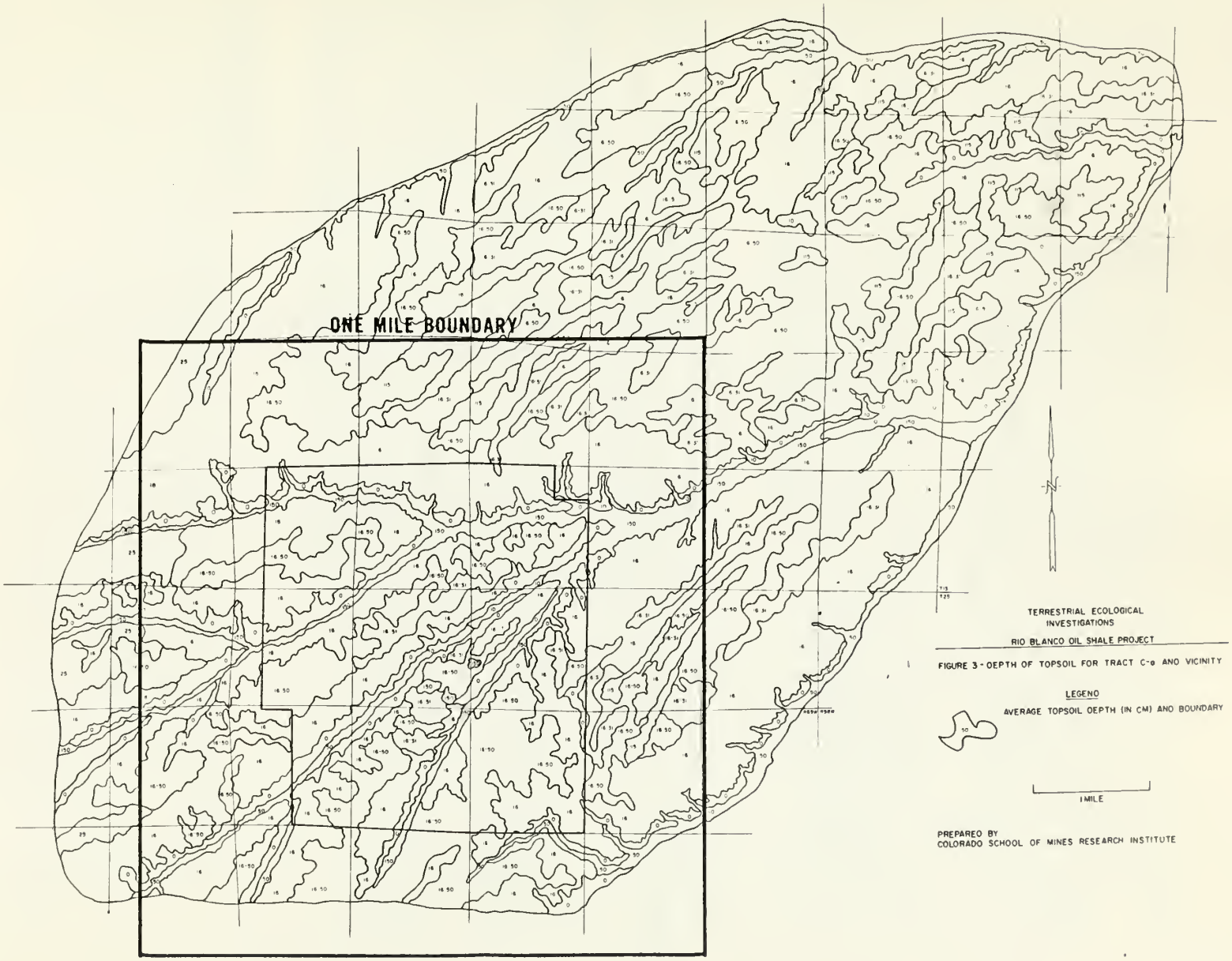

ONE MILE BOUNDARY
TERRESTRIAL ECOLOGICAL
INVESTIGATIONS
RIO BLANCO OIL SHALE PROJECT
FIGURE 3 - DEPTH OF TOPSOIL FOR TRACT C-a AND VICINITY
LEGEND
AVERAGE TOPSOIL DEPTH (IN CM) AND BOUNDARY
1 MILE
PREPARED BY
COLORADO SCHOOL OF MINES RESEARCH INSTITUTE

FIGURE I-2

areas where the surface soil has an electrical conductivity of 8.0 mmhos/cm or more), but the time span may not be acceptable. Sodic soils restrict plant germination and growth and although this restriction may not be great, it could complicate and delay revegetation. A certain amount of rock can be tolerated in topsoil, but excessive amounts present problems in the movement, grading, and seeding of topsoiled spoils.

The following is a discussion of the suitability of the topsoil of the five major soil series as a plant growth medium. The soil types discussed include the three soil types (Rentsac, Piceance, Redcreek) which will be affected by mining activities (Figure C-5*).

The Corral Gulch Reservoir (Figure F-1*)will be located in an area of Havre soils. Since the impoundment will be permanent, these soils will not be used for reclamation activities and are not discussed in this section.

Rentsac Series

The Rentsac series is sodic below the 50 cm depth and would not serve well as topsoil. The chemical properties of the surface 50 cm are nonrestrictive to plant growth (Table I-2). However, considerable rock is found in the 10-50 cm interval. Depth to rock ranges from 5 to 50 cm and averages 16 cm. Thus, only the surface 16 cm of the Rentsac series is suitable for use as topsoil. Individual sites within the study area where the surface 16 cm has undesirable chemical properties were not found.

Piceance Series

On the basis of the average chemical traits of this series (Table I-2), only the 100-150 cm depth would be unsuitable for use as topsoil. This depth is both saline and sodic. Depth to rock averages 50 cm and ranges from 30 to 100 cm. Within the Piceance series no sites were found where the chemical traits of the surface 50 cm of soil were unsuited for use as topsoil. Therefore, 50 cm of topsoil is available, on the average, in the Piceance series.

Torriorthent Series

Based on the average chemical traits (Table I-2), the degree of salinity of this series precludes its use as topsoil. In addition, rock is found within the first 10 cm.

* See Volume II

Glendive Series

The physical and chemical characteristics indicate that the Glendive series is generally suitable for use as topsoil down to a depth of at least 150 cm (Table I-2). These soils were essentially free of rock. However, several sampling sites in the Glendive series contained material not suited for use as topsoil due to saline or sodic conditions. These sites were located along Box Elder Gulch which will not serve as a source of topsoil material during the MDP. Therefore, the Glendive series located in the area of MDP mining activities will provide adequate topsoil material.

Redcreek Series

The chemical properties of the Redcreek series, as presented in Table I-2 would not restrict the use of these soils as a source of topsoil in the reclamation program. Depth to rock ranges from 8 to 50 cm and averages 31 cm. Thus, suitable topsoil is available to a depth of 31 cm at locations on Tract C-a.

The surface soils in the study area which are considered suitable material for plant growth have nitrogen and phosphorus levels averaging 13 ppm. Plants should have an adequate supply of these two macronutrients at all times, but an adequate supply is especially critical during the early stages of revegetation. The nitrogen concentration is relatively low and an application of approximately 30 pounds per acre of elemental nitrogen is recommended. The concentration of plant-available phosphorus appears adequate, but the soil should be tested prior to actual revegetation efforts to determine the phosphorus status. If the level is less than 10 ppm, phosphorus fertilizer should be applied to the soil. Other macro- and micronutrients occur in adequate to ample concentrations to support normal plant growth.

Thus, soil material suitable for plant growth varies in depth from less than 0.5 m to over 1.5 m. Rock is the primary factor limiting use of certain soils for reclamation. Although most soils in the study area,

with the exception of soils of the Rock Outcrop-Torriorthent complex, appeared to have some surface soil suitable for plant growth, the Glendive series appeared to have the best balance of nutrients and the greatest depth of suitable soil material.

LITERATURE CITED

RBOSP. 1977. Final Environmental Baseline Report for Tract C-a and Vicinity. Gulf-Standard. Denver, Colorado. Attachment G-2.

ATTACHMENT I-1

SOIL SERIES DESCRIPTION FOR THE FIVE MAJOR SOIL TYPES

Rentsac Series

Soils of the Rentsac series are shallow, skeletal, well drained, and formed in residuum from sandstone that is usually horizontally fractured. These soils typically occur on foothills and ridge tops where slopes range from 5 to 50%.

The A horizon is typically a pale brown very channery sandy loam or loam approximately 10 cm thick. Coarse fragments range from 25 to 40% of the total, with most of the fragments being less than 8 cm in diameter. The underlying layer is a pale brown very channery sandy loam or loam about 16 cm thick. This layer has 60% coarse fragments with approximately 10% of the fragments larger than 8 cm in diameter. The substrata is a pale brown extremely channery sandy loam about 16 cm thick and overlies fractured hard sandstone.

Rentsac soils have rapid permeability. Effective rooting depth is less than 50 cm. The organic matter content in the surface horizon is medium. Available water-holding capacity is low. Surface runoff is medium and erosion hazard ranges from slight to moderate. These soils are calcareous and moderately alkaline throughout. Lime coatings can be found on the underside of coarse fragments in the subsurface horizons.

The dominant vegetation on the Rentsac series is either pinyon-juniper or big sagebrush. Other woody plants commonly found include mountain mahogany, serviceberry, and bitterbush. Herbaceous vegetation includes western wheatgrass, elk sedge, needle-and-thread, Nevada bluegrass, Indian ricegrass, squirreltail, hollyleaf clover, western wallflower, and others. With very few exceptions, soils of the Rentsac series are used for wildlife habitat and livestock grazing.

A typical pedon of the Rentsac series was found in the NE¼, NE¼, Section 10, T2S, R99W. A description of this pedon follows:

A1--0 to 11 cm; grayish brown (10 YR 5/2) channery loam; dark brown (10 YR 3/3) when moist; weak medium subangular block parting to weak fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; 40 % sandstone channery; calcareous, moderately alkaline; clear smooth boundary.

AC--11 to 25 cm; very pale brown (10 YR 7/3) very channery loam; brown (10 YR 3/3) when moist; weak fine granular structure; soft, friable, slightly sticky and slightly plastic; 60% sandstone channery; calcareous, moderately alkaline; clear wavy boundary.

Cr--25 to 42 cm; very pale brown (10YR 8/3) extremely channery loam; light yellowish brown (10 YR 6/4) when moist; massive; soft, friable, slightly sticky and slightly plastic; 70% sandstone channery; calcareous, moderately alkaline; clear wavy boundary.

R--42 cm; highly fractured very pale brown Uinta sandstone; 20% of the voids are filled with loam as described above.

The genetic horizons of this Rentsac profile are nonsaline and nonsodic. The R horizon is bedrock which is presumably like the parent rock in the C horizon from which the adjacent overlying horizons were formed. This material is saline, sodic, and very strongly alkaline. The concentration of most macronutrients is lower than the concentration found for the study area, but these appear to be adequate amounts of macronutrients for normal plant growth. Micronutrients occur in concentrations considered ample for plant needs. This profile contained relatively high percentages of organic matter. Both the AC and the Cr horizons contained considerable rock and roots were concentrated in the unconsolidated part and, therefore, contained considerable amounts of organic matter. Roots were essentially absent in the R horizon. The concentration of trace elements was within the ranges considered normal for surface soils. Physical properties were within the ranges expected and considered typical for this area.

Piceance Series

Soils of the Piceance series are moderately deep, well drained, and have formed in residuum from sandstone and modified with aeolian material.

These soils are found on upland slopes and on the lee side of ridges. Slope ranges from 5 to 15%.

Typically, the surface horizon of Piceance soils is a brown loam or sandy loam ranging from 10 to 25 cm thick. The subsoil or B horizon is a brown or light brown silt loam approximately 40 cm thick. The substratum is a pale brown channery loam about 30 cm thick and overlies hard sandstone. There is a layer of lime accumulation in the lower part of the B horizon and in the substratum.

Permeability is rapid and the effective rooting depth is 50 to 100 cm. The available water capacity is moderate. Organic matter content in the surface layer is medium. Surface runoff is slow to medium and the erosion hazard is slight to moderate.

Big sagebrush is the dominant form of vegetation on soils of the Piceance series. Other vegetation commonly found includes rabbitbrush, needle-and-thread, Indian ricegrass, muttongrass, Sandberg bluegrass, wheatgrasses, lupine, hollyleaf clover, phlox, fleabane, buckwheat, and others. Livestock grazing and wildlife habitat are the dominant uses of these soils.

A typical pedon of the Piceance series was located in the NE¼, NW¼, Section 10, T2S, R99W, and is described below.

A1--0 to 10 cm; brown (10 YR 5/3) loam, dark brown (10 YR 3/3) when moist; medium fine granular structure; slightly hard, very friable, slightly plastic and slightly sticky; common fine and very fine roots; noncalcareous, mildly alkaline; clear smooth boundary.

B1--10 to 36 cm; brown (10 YR 5/3) silt loam; dark brown (10 YR 4/3) when moist; weak moderate subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common fine and very fine roots; noncalcareous, moderately alkaline; clear wavy boundary.

B2--36 to 53 cm; brown (10 YR 5/3) silt loam, dark brown (10 YR 4/3) when moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine and very fine roots, calcareous, moderately alkaline; clear wavy boundary.

C1--53 to 81; pale brown (10 YR 6/3) loam , dark brown (10 YR 4/3) when moist; massive, slightly hard, friable, slightly sticky and slightly plastic; common very fine roots; free lime visible; highly calcareous, strongly alkaline; clear wavy boundary.

R--81 cm; hard sandstone.

These four horizons were nonsaline and nonsodic. The concentrations of nitrogen and extractable phosphorus were relatively low in the subsurface horizons, but not at a level where plant growth would be noticeably affected. Percentage organic matter, the concentration of trace elements, and physical traits were within expected ranges.

Torriorthent

This unnamed Torriorthent series consists of soils which have formed in colluvial and alluvial material originating from calcareous sandstone or shale. These shallow, well drained soils are generally found on very steep, south-facing slopes and canyon bluffs.

The A horizon ranges from very pale brown to brown sandy loam to silt loam, and contains varying amounts of rock fragments. Subsurface horizons are generally light colored very channery silt loam or loamy sand. Considerable variation is found in almost all soil traits of the Torriorthents. The nature of the parent material, steepness of the slope, aspect, and vegetation vary considerably within this soil type and are major factors in the variable nature of this soil type.

The vegetation occurring on this soil type is sparse. Common components of the vegetation include pinyon pine, Utah juniper, greasewood, shadscale, rabbitbrush, woody buckwheat, Indian ricegrass, primrose, fringe sage, blue-bunch wheatgrass, and silver thistle. These soils have severe limitations for essentially all uses, but do serve as a limited wildlife habitat.

Following is a description of a Torriorthent pedon occurring in the SE¼, SW¼ Section 34, T1S, R99W.

A1--0 to 11 cm; very pale brown (10 YR 7/3) light silt loam, yellowish brown (10 YR 5/4) when moist; massive; soft, very friable, slight sticky and slightly plastic; highly calcareous, very stongly alkaline; clear smooth boundary.

AC--11 to 37 cm; light gray (10 YR 7/2) very fine channery silt loam; brown (10 YR 5/3) when moist; massive; soft, very friable, nonsticky and nonplastic; highly calcareous, strongly alkaline; clear wavy boundary; 15% is variegated (5 YR 5/8).

Cr--37 to 49 cm; very pale brown (10 YR 7/3) very channery silt loam; dark brown (10 YR 4/3) when moist; massive; soft very friable, nonsticky and nonplastic; highly weathered Green River shale; highly calcareous, moderately alkaline; 15% is variegated (5 YR 5/8); clear wavy boundary.

R--49 cm; Green River shale.

The most striking chemical traits of this Torriorthent are the highly saline and highly sodic nature of this soil. These traits severely restrict plant growth and are undoubtably important factors in the sparse vegetative cover on Torriorthent soils. It appears that these traits are primarily a function of the parent material. The water-soluble macronutrients, especially sulfate, are considerably more concentrated in this Torriorthent soil than in the soils of the study area. The concentration of nitrate is also unusually high. Micronutrient concentration is within the range expected, although extractable copper is somewhat more abundant in this profile than in the other soils. Organic matter is low, as expected, due to the sparse vegetative cover. This profile has been only slightly weathered and most of the chemical and physical traits appear to reflect the nature of the parent material.

Glendive Series

The Glendive series consists of soils which are deep, well drained, and which have formed in alluvium, weathered mainly from sedimentary bedrock. These soils are found in narrow valley bottoms and have slopes ranging from 2 to 15%.

The surface A horizon typically is a pale brown silt loam ranging from 12 to 30 cm deep. The underlying material is stratified silt loams, sandy loams, and loamy sands that extend to a depth of 150 cm or deeper.

Water permeability is moderate and the effective rooting depth is 150 cm or more. Available water capacity is moderate. Organic matter content in the surface horizon is medium. Surface runoff is slow and the erosion hazard is rated as moderate. These soils are calcareous throughout and reaction ranges from moderately to strongly alkaline. Coarse fragments, less than 1 inch in diameter, make up 5 to 15% of the 25 to 100 cm depth.

Glendive soils are generally dominated by big sagebrush. In areas that have been burned, rabbitbrush and sometimes greasewood dominate. Common herbaceous species include basin wildrye, western wheatgrass, streambank wheatgrass, Indian ricegrass, squirreltail, and Nevada bluegrass. These soils are generally used for livestock grazing and wildlife habitat. These soils form an important part of the mule deer winter range. Some areas of this series are irrigated and used for forage production.

A Glendive pedon considered typical of the series was located on Tract C-a in the SW¼, NE½, Section 34, T1S, R99W. This pedon was described as follows:

A1--0-13 cm; pale brown (10 YR 6/3) silt loam, dark brown (10 YR 4/3) when moist; weak fine granular parting to weak coarse platy structure; soft, very friable, nonsticky and nonplastic; common fine roots; calcareous, moderately alkaline; clear smooth boundary.

C1--13 to 53 cm; pale brown (10 YR 6/3) fine channery silt loam; dark brown (10 YR 4/3) when moist; weak medium subangular blocky parting to weak fine granular structure; soft, very friable, nonsticky and nonplastic; common fine roots; calcareous, moderately alkaline; clear wavy boundary.

C2--53 to 80 cm; very pale brown (10 YR 7/3) very fine channery silt loam; pale brown (10 YR 6/3) when moist; massive; soft, very friable; nonsticky and nonplastic; common fine roots; free calcium visible; strongly calcareous, moderately alkaline; clear wavy boundary.

C3--80 to 115 cm; very pale brown (10 YR 7/3) fine channery silt loam; brown (10 YR 5/3) when moist; massive; soft, very friable, nonsticky and nonplastic; common fine roots; strongly calcareous, moderately alkaline; clear wavy boundary.

C4--115 to 139 cm; pale brown (10 YR 6/3) silt loam; dark brown (10 YR 4/3) when moist; massive; soft, very friable, nonsticky and nonplastic; common fine roots; calcareous, moderately alkaline; clear wavy boundary.

C5--139 to 174 cm; pale brown (10 YR 6/3) fine channery silt loam; dark brown (10 YR 4/3) when moist; massive; soft, very friable, slightly sticky and slightly plastic; few fine roots; calcareous, moderately alkaline.

All horizons were nonsodic with the exception of the nonsaline C5 horizon. The accumulation of salts at this depth should not have any measurable effect on plant growth. Plant nutrients are present in generally adequate quantities. Some horizons are relatively low in nitrogen and phosphorus, but these seem to be sufficient in nitrogen and phosphorus when the entire profile is considered. No unusual concentrations of trace elements were detected in the horizons. Physical properties did not display much variation from horizon to horizon.

Redcreek Series

The Redcreek series consists of shallow, well drained soils that have formed in sandy material weathered from underlying calcareous, massive sandstone. These soils are found on foothills and ridge tops where slopes range from 5 to approximately 30%.

The A horizon is a pale brown to brown sandy loam about 14 cm thick. The underlying horizon is a pale to light brown channery sandy loam. Substrata is a channery to very channery sandy loam ranging from 35 to 80 cm thick. Coarse fragments account for as much as 80% of the material found in the lower portions of the substrata. Permeability is moderately rapid, the available water capacity is low, and the effective rooting depth ranges from 25 to 50 cm. Surface runoff is slow, and the erosion hazard is slight. Reaction is mildly alkaline to moderately alkaline throughout; all horizons are calcareous. Lime coatings on the surface of rocks can be found in the lower portions of the substrata.

The vegetation on these soils is typically dominated by pinyon pine and Utah juniper. Understory species commonly include big sagebrush, serviceberry, mountain mahogany, bluebunch wheatgrass, elk sedge, squirreltail,

Indian ricegrass, Junegrass, loco and buckwheat. Use of these soils includes livestock grazing and wildlife habitat.

A pedon considered typical of the Redcreek series was found on Tract C-a and was located in the NW¼, NE¼, Section 4, T2S, R99W. This pedon was described as follows:

A0--3 cm; partially decomposed tree litter.

A1--0 to 13 cm; brown (7.5 YR 5/4) sandy loam, dark brown (7.5 YR 4/2) when moist; weak fine subangular blocky parting to moderate fine granular structure; soft, very friable, nonsticky and nonplastic; noncalcareous, moderately alkaline; clear smooth boundary.

AC--13 to 23 cm; light brown (7.5 YR 6/4) sandy loam; dark brown (7.5 YR 4/4) when moist; weak medium subangular blocky parting to weak fine granular structure; 5% fine channery; soft, very friable, nonsticky and nonplastic; calcareous, moderately alkaline; clear wavy boundary.

C1--23 to 42 cm; light yellowish brown (10 YR 6/4) sandy loam; dark yellowish brown (10 YR 4/4) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; 10% channery; common fine roots; some lime accumulation on coarse fragments; calcareous, moderately alkaline; clear wavy boundary.

Crca--42 to 102 cm; white (10 YR 8/2) light sandy loam; very pale brown (10 YR 7/3) when moist; massive; slightly hard, very firm slightly sticky and nonplastic; fractured sandstone with lime enrichment; 20% of the voids are filled with calcareous sandy loam material; highly calcareous, moderately alkaline; clear wavy boundary.

R--102 cm; sandstone bedrock.

These genetic horizons were both nonsaline and nonsodic. The concentration of plant nutrients was within the range expected, with the exception of extractable phosphorus in the surface epipedon. For unknown reasons, the phosphorus in this horizon was relatively high. The slight increase in percentage organic matter in the Crca horizon was caused by roots being concentrated in the unconsolidated portion of the horizon.

EXHIBIT
J

EXHIBIT J

VEGETATION INFORMATION

EXHIBIT J - VEGETATION INFORMATION

Vegetation baseline studies were conducted on Tract C-a and the surrounding 5-mile area from October 1974 through September 1976. The detailed results of these studies are presented in the RBOSP Terrestrial Annual Report (1976) and the RBOSP Progress Report 10 (1977).

a. Description of Existing Vegetation

Eight vegetation types (aspen, Douglas-fir, pinyon-juniper, mixed brush, sagebrush, bald, shadscale, and riparian) were identified within the Tract C-a study area (Figure J-1*, inserted in pocket). A detailed map (1" = 500') of the vegetation types occurring in areas affected by mining activities is presented in Exhibit C (Figure C-4)*. Pinyon-juniper and sagebrush are the dominant vegetation types and were subdivided into associations, based on topographic and physiognomic criteria. The extent and general information (elevation, aspect, soil condition, dominant species) of each vegetation type/association is presented in Table J-1.

The flora identified in the Tract C-a study area includes six tree species, 29 shrub species and 186 herbaceous species, of which 45 species are classified as grass or grass-like. A list of these species is presented in Attachments J-1 and J-2.

A milkvetch (Astragalus lutosus) formerly on the endangered plant species list (USDI 1975) was located off-tract near Cottonwood Springs on Big Duck Creek.

A detailed description of each of the vegetation types follows:

(i) Aspen

The aspen type on the study area is characterized by the constant presence of aspen trees ranging from five to ten meters in height, and dense and diverse shrub and herbaceous strata consisting primarily of serviceberry (Amelanchier sp) in the shrub stratum, and elk sedge (Carex geyeri) in the herbaceous stratum.

* See Volume II

TABLE J-1

GENERAL INFORMATION REGARDING VEGETATION TYPES AND ASSOCIATIONS SAMPLED IN THE TRACT C-a VICINITY DURING 1974-1976 FOR RBOSP

Vegetation Type	Elevation	Exposure	Extent in Study Area	Soil Condition	Dominant Species
Aspen	2435 m (8,000 ft)	north- and east facing	961 acres (<1%)	deep, sandy loams with large accumulations of organic matter	serviceberry sp elk sedge
Douglas-fir	2380 m (7,800 ft)	north- and east facing	1,598 acres (1%)	shallow soils	Douglas-fir serviceberry snowberry elk sedge
Mixed brush	2100-2250 m (7,000-8,500 ft)	all slope aspects	27,388 acres (25%)	deep, sandy loams and shallow soils above shale outcroppings	Utah serviceberry big sagebrush elk sedge
Pinyon-juniper woodland	1950-2250 m (6,500-7,500 ft)	all slope aspects	621 acres (<1%)	Rentsac soil series	pinyon juniper sandberg bluegrass slender wheatgrass
Pinyon-juniper mixed brush	2100-2250 m (7,000-7,500 ft)	north- and south facing	24,258 acres (22%)	Rentsac soil series	pinyon juniper Utah serviceberry big sagebrush sandberg bluegrass
Pinyon-juniper sagebrush	1950-2250 m (6,500-7,500 ft)	all slope aspects	20,288 acres (18%)	Rentsac soil series	juniper pinyon big sagebrush sandbergh bluegrass slender wheatgrass
Sagebush upland	1950-2550 m (6,500-8,500 ft)	all slope aspects	21,527 acres (20%)	Rentsac, Piceance, and Yamac soils series	big sagebrush Douglas rabbitbrush sandberg bluegrass Hood phlox
Sagebrush bottomland	1950-2550 m (6,500-8,500 ft)	all slope aspects	7,262 acres (7%)	Glendive soil series	big sagebrush Douglas rabbitbrush western wheatgrass Great Basin wildrye
Sagebrush greasewood	1950-2550 m (6,500-8,500 ft)	slope aspects characteristic of study area drainages	1,087 acres (1%)	alluvial soils	greasewood big sagebrush rubber rabbitbrush cheatgrass goosefoot
Sagebrush rabbitbrush	1950-2550 m (6,500-8,500 ft)	slope aspects characteristic of study area drainages	679 acres (<1%)	alluvial soils	rabbitbrush Great Basin wildrye goosefoot cheatgrass
Bald	2170-2565 m (7,230-8,550 ft)	west facing	2,087 acres (2%)	Rentsac soil series	Utah serviceberry green rabbitbrush sandberg bluegrass slender wheatgrass prairie junegrass
Shadscale	1938-2045 m (6,460-6,810)	steep south facing slope adjacent to major drainages	1,280 acres (1%)	rock outcrops or very shallow soils	shadscale big sagebrush eriogonum fringed sagewort
Riparian	1950-2250 m (6,500-7,500 ft)	all slope aspects	185 acres (<1%)	wet	big sagebrush water birch quackgrass Kentucky bluegrass

The type occurs in isolated patches just east of Cathedral Bluffs on the western edge of the study area at elevations generally above 2435 m (8,000 ft) on steep north-and east-facing slopes (Figure J-1*). The majority of aspen clones are located in the lee of the prevailing wind below ridge crests along Cathedral Bluffs. The aspen type is also bordered by the mixed brush type on drier slopes. Tall shrub species of the mixed brush type are common constituents of the aspen shrub stratum.

The aspen tree stratum consists almost exclusively of one species, aspen, which provided 44 percent and a density of 594 individuals per hectare on the transects sampled (Table J-2). The larger number of aspen are saplings and there is a lack of mature trees in size classes greater than 24 cm (9.4 inch).

The diverse (14 species) shrub stratum is dominated by Saskatoon and Utah serviceberry. These species together provide 34 percent of the 72 percent total cover afforded by the shrub stratum. Common black chokecherry (Prunus virginiana; 9 percent cover), is also present. Mountain snowberry (Symphoricarpos oreophilus) was found in moist sites within the aspen type.

Herbaceous cover varied in quadrats sampled from less than 10 percent in the spring, to greater than 40 percent in the summer, and declined to approximately 20 percent in the fall (Figure J-2). Cover values were similar for the same seasons during the two years of the study. Less than 20 species were sampled during the spring, increasing to 25 in the summer, and declining to approximately 20 in the fall. Elk sedge was the most important species in the aspen type, appearing as a dominant at all seasons, and contributing the majority of the herbaceous cover during the spring and fall (Table J-3). Canada violet (Viola canadensis), mountain thermopsis (Thermopsis montana), and sweetroot (Osmorhiza depauperata) contributed a large proportion of the cover during the summer.

* See Volume II

TABLE J-2
QUANTITATIVE DATA FOR TREE AND SHRUB SPECIES OCCURRING IN VEGETATION TYPES AND ASSOCIATIONS IDENTIFIED FOR RBOSP, 1975-1976.

SPECIES	VEGETATION TYPES AND ASSOCIATIONS														
	ASPEN (8 transects)					DOUGLAS-FIR (8 transects)					MIXED BRUSH (29 transects)				
TREE STRATUM	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.
1. Aspen (Pooulus tremuloides)	44.3	5.4	594	16.3	92	.4	.4	2	.1	1					
2. Douglas-fir (Pseudotsuga menziesii)	2.0	1.1	21	1.0	8	49.9	8.4	394	22.9	99	1.0	1.0			
3. Utah juniper (Juniperus osteosperma)															
4. Pinyon pine (Pinus edulis)											.5	.4		.5	
Totals	46.3		615	17.3		50.3		396	23.0		1.5				
Number of Species	2														
SHRUB STRATUM															
1. Antelope bitterbrush (Purshia tridentata)											1.7	.6	462	5	-
2. Aspen (Populus tremuloides)	6.7	2.7	815	10	-										
3. Big sagebrush (Artemisia tridentata)	.2	.2	146	1	-	.1	.1	38	1	-	9.5	1.1	3870	22	-
4. Broom snakeweed (Gutierrezia sarothrae)															
5. Common chokecherry (Prunus virginiana)	8.5	2.9	1485	12	-	8.0	4.4	898	10	-	.7	.5	109	1	-
6. Common winterfat (Eurotia lanata)															
7. Creeping barberry (Mahonia repens)															
8. Douglas-fir (Pseudotsuga menziesii)	.1	.1	25	1	-	5.6	2.0	2798	17	-					
9. Douglas rabbitbrush (Chrysothamnus viscidiflorus)											.6	.1	989	7	-
10. Fourwing saltbush (Atriplex canescens)															
11. Fringed sage (Artemisia frigida)															
12. Gambel oak (Quercus gambelii)						3.0	1.4	506	5	-	4.5	1.2	279	5	-
13. Golden currant (Ribes aureum)															
14. Gray horsebrush (Tetradymia canescens)											.1	.1	367	3	-
15. Greasewood (Sarcobatus vermiculatus)															
16. Green ephedra (Ephedra viridis)															
17. Martin ceanothus (Ceanothus martini)															
18. Mountain lover (Pachystima myrsinites)	.1	.1	390	2	-	.3	.3	731	3	-					
19. Mountain snowberry (Symphoricarpos oreophilus)	18.4	3.9	4310	25	-	14.5	2.4	4317	27	-	10.7	1.7	3640	22	-
20. Ocean-spray (Holodiscus dumosus)						0.0	.0	33	1	-					
21. Pinyon pine (Pinus edulis)											.1	.0	35	1	-
22. Plains prickly pear (Opuntia polyacantha)															
23. Red willow (Salix exigua)															
24. Rocky Mountain maple (Acer glabrum)	2.9	1.8	158	4	-	1.	.6	65	2	-					
25. Rubber rabbitbrush (Chrysothamnus nauseosus)															
26. Saskatoon serviceberry (Amelanehier alnifolia)	11.8	7.8	854	9	-	7.4	4.9	296	7	-	.7	.7	132	1	-
27. Shadscale (Atriplex confertifolia)															
28. True mountain mahogany (Cercocarpus montanus)											1.9	.8	308	3	-
29. Utah juniper (Juniperus osteosperma)															
30. Utah serviceberry (Amelanehier utahensis)	15.8	6.9	717	13	-	15.2	5.7	990	16	-	26.9	2.6	2418	28	-
31. Water birch (Betula fontinalis)															
32. Wax currant (Ribes cereum)	.7	.7	69	2	-	.3	.3	44	1	-					
33. Whitestem gooseberry (Ribes inerme)	.9	.8	1163	5	-	1.1	1.1	390	2						
34. Willow (Salix interior)															
35. Woods rose (Rosa woodsii)	4.9	1.9	2744	15	-	.6	.3	669	5	-					
Totals	72.0		13194			57.4		16885			57.9		12710		
Number of Species	14					20					21				

TABLE J-2 (Continued)
QUANTITATIVE DATA FOR TREE AND SHRUB SPECIES OCCURRING IN VEGETATION TYPES AND ASSOCIATIONS IDENTIFIED FOR RBOSP, 1975-1976.

VEGETATION TYPES AND ASSOCIATIONS

SPECIES	PINYON JUNIPER														
	PJ - WOODLAND (16 transects)					PJ - MIXED BRUSH (17 transects)					PJ - SAGEBRUSH (16 trans)				
TREE STRATUM	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp Val
1. Aspen (Populus tremuloides)															
2. Douglas-fir (Pseudotsuga menziesii)															
3. Utah juniper (Juniperus osteosperma)	10.5	1.5	178	32.8	51	7.5	2.2	78	20.9	39	9.6	1.6	166	23.2	63
4. Pinyon pine (Pinus edulis)	14.4	2.4	145	16.4	49	12.9	2.3	124	12.5	61	7.3	2.3	83	3.3	37
Totals	24.9					20.4					16.9				
Number of Species															
SHRUB STRATUM															
1. Antelope bitterbrush (Purshia tridentata)	.9	.3	270	20	-	2.0	.8	412	9	-	.3	.2	48	2	-
2. Aspen (Populus tremuloides)															
3. Big sagebrush (Artemisia tridentata)	.5	.2	331	18	-	5.3	1.1	1983	27	-	6.8	1.0	3113	52	-
4. Broom snakeweed (Gutierrezia sarothrae)						0.0	0.0	87	1	-	.1	.1	136	2	-
5. Common chokecherry (Prunus virginiana)															
6. Common winterfat (Eurotia lanata)											.0	.0	80	1	-
7. Creeping barberry (Mahonia repens)															
8. Douglas-fir (Pseudotsuga menziesii)						.3	.1	419	6	-					
9. Douglas rabbitbrush (Chrysothamnus viscidiflorus)	.3	.1	185	10	-						.4	.1	502	9	-
10. Fourwing saltbush (Atriplex canescens)															
11. Fringed sage (Artemisia frigida)	.0	.0	17	1	-										
12. Gambel oak (Quercus gambelii)															
13. Golden currant (Ribes aureum)															
14. Gray horsebrush (Tetradymia canescens)	.0	.0	57	3	-	..0	.0	62	1	-	.0	.0	103	3	-
15. Greasewood (Sarcobatus vermiculatus)											.0	.0	36	1	-
16. Green ephedra (Ephedra viridis)															
17. Martin ceanothus (Ceanothus martini)						.0	.0	56	1	-					
18. Mountain lover (Pachystima myrsinites)															
19. Mountain snowberry (Symphoricarpos oreophilus)	.0	.0	6	1	-	.6	.2	319	6	-	.0	.0	14	1	-
20. Ocean-spray (Holodiscus dumosus)															
21. Pinyon pine (Pinus edulis)	.7	.3	229	18	-	1.3	.4	389	10	-	.3	.2	231	7	-
22. Plains prickly pear (Opuntia polyacantha)	.1	.0	57	4	-	.1	.0	72	2	-	.1	.0	188	5	-
23. Red willow (Salix exigua)															
24. Rocky Mountain maple (Acer glabrum)															
25. Rubber rabbitbrush (Chrysothamnus nauseosus)	.1	.1	43	3	-	.1	.1	68	2	-	.2	.1	178	4	-
26. Saskatoon serviceberry (Amelanchier alnifolia)						.6	.4	135	3	-					
27. Shadscale (Atriplex confertifolia)	.1	.1	68	4	-	.2	.2	155	2	-	.0	.0	54	1	-
28. True mountain mahogany (Cercocarpus montanus)	.4	.2	109	9	-	1.4	.5	361	7	-	.1	.1	49	1	-
29. Utah juniper (Juniperus osteosperma)	.4	.2	39	7	-	.4	.2	93	4	-	.7	.3	113	7	-
30. Utah serviceberry (Amelanchier utahensis)	.0	.0	32	2	-	5.7	1.4	751	19	-	.2	.1	151	4	-
31. Water birch (Betula fontinalis)															
32. Wax currant (Ribes cereum)															
33. Whitestem gooseberry (Ribes inerme)															
34. Willow (Salix interior)															
35. Woods rose (Rosa woodsii)															
Totals	3.5		1453			18.1		5388			9.2		5022		
Number of Species	15					17					16				

TABLE J-2 (Continued)
QUANTITATIVE DATA FOR TREE AND SHRUB SPECIES OCCURRING IN VEGETATION TYPES AND ASSOCIATIONS IDENTIFIED FOR RBOSP, 1975-1976.

VEGETATION TYPES AND ASSOCIATIONS

SAGEBRUSH

SPECIES	UPLAND SAGEBRUSH (33 transects)					BOTTOMLAND SAGEBRUSH (14 trans.)					GREASEWOOD (6 transects)					RABBITBRUSH (8 transects)				
TREE STRATUM	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.
1. Aspen (Populus tremuloides)																				
2. Douglas-fir (Pseudotsuga menziesii)																				
3. Utah juniper (Juniperus osteosperma)	0	0	11	1.9	44															
4. Pinyon pine (Pinus edulis)	0	0	6	.3	22															
Totals																				
Number of Species																				
SHRUB STRATUM																				
1. Antelope bitterbrush (Purshia tridentata)	.2	.1	29	1	-															
2. Aspen (Populus tremuloides)	.1	.0	133	1	-															
3. Big sagebrush (Artemisia tridentata)	31.1	9.4	6980	55	-	32.7	3.1	9633	52	-	10.4	4.3	2981	29	-	1.8	.8	4025	21	-
4. Broom snakeweed (Gutierrezia sarothrae)	.2	.2	76	1	-															
5. Common chokecherry (Prunus virginiana)																				
6. Common winterfat (Eurotia lanata)	.1	.0	159	2	-	.7	.6	1365	5	-										
7. Creeping barberry (Mahonia repens)																				
8. Douglas-fir (Pseudotsuga menziesii)																				
9. Douglas rabbitbrush (Chrysothamnus viscidiflorus)	2.0	.5	2691	16	-	3.4	1.7	3750	15	-	.1	.1	111	4	-	21.3	3.5	3638	35	-
10. Fourwing saltbush (Atriplex canescens)						.1	.1	39	1	-										
11. Fringed sage (Artemisia frigida)																				
12. Gambel oak (Quercus gambelii)																				
13. Golden currant (Ribes aureum)						.1	.1	112	1	-										
14. Gray horsebrush (Tetradymia canescens)	.1	.1	152	2	-	.0	.0	45	1	-										
15. Greasewood (Sarcobatus vermiculatus)	.0	.0	44	1	-	1.1	.6	287	3	-	29.5	3.4	4556	50	-	2.0	1.2	419	7	
16. Green ephedra (Ephedra viridis)																				
17. Martin ceanothus (Ceanothus martini)																				
18. Mountain lover (Pachystima myrsinites)																				
19. Mountain snowberry (Symphoricarpos oreophilus)	1.8	.7	455	6	-															
20. Ocean-spray (Holodiscus dumosus)																				
21. Pinyon pine (Pinus edulis)	.1	.0	39	2	-															
22. Plains prickly pear (Opuntia polyacantha)	.1	.0	127	3	-	.0	.0	98	1	-										
23. Red willow (Salix exigua)																				
24. Rocky Mountain maple (Acer glabrum)																				
25. Rubber rabbitbrush (Chrysothamnus nauseosus)	.9	.7	281	3	-	3.8	1.8	1313	9	-	3.7	2.3	1742	14	-	14.5	5.9	5754	36	-
26. Saskatoon serviceberry (Amelanchier alnifolia)																				
27. Shadscale (Atriplex confertifolia)						.3	.3	107	2	-	.1	.1	114	4	-					
28. True mountain mahogany (Cercocarpus montanus)																				
29. Utah juniper (Juniperus osteosperma)	.0	.0	26	1	-															
30. Utah serviceberry (Amelanchier utahensis)	1.8	.8	357	6	-	.3	.3	74	2	-										
31. Water birch (Betula fontinalis)																				
32. Wax currant (Ribes cereum)																				
33. Whitestem gooseberry (Ribes inerme)																				
34. Willow (Salix interior)																				
35. Woods rose (Rosa woodsii)																				
Totals	38.5		11608			45.5		17914			43.9		9504			39.5		13840		
Number of Species	23					15					4					6				

TABLE J-2 (Continued)
QUANTITATIVE DATA FOR TREE AND SHRUB SPECIES OCCURRING IN VEGETATION TYPES AND ASSOCIATIONS IDENTIFIED FOR RBOSP, 1975-1976.

SPECIES	VEGETATION TYPES AND ASSOCIATIONS: BALD (20 transects)					SHADSCALE (5 transects)					RIPARIAN (15 transects)				
	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.	% Cover	STD ERR	Density HA	B.A. M^2/HA	Imp. Val.
TREE STRATUM															
1. Aspen (Populus tremuloides)															
2. Douglas-fir (Pseudotsuga menziesii)															
3. Utah juniper (Juniperus osteosperma)						4.3	0.0	50	3.4	100					
4. Pinyon pine (Pinus edulis)	0	0	50	11.5	67										
Totals															
Number of Species															
SHRUB STRATUM															
1. Antelope bitterbrush (Purshia tridentata)															
2. Aspen (Populus tremuloides)											2.1	2.1	8	4	4
3. Big sagebrush (Artemisia tridentata)	.3	.1	254	9	-	7.5	3.7	1317	32	-	8.4	2.7	1931	26	-
4. Broom snakeweed (Gutierrezia sarothrae)	.4	.3	1165	1	-										
5. Common chokecherry (Prunus virginiana)											.8	.4	132	3	-
6. Common winterfat (Eurotia lanata)	.1	.1	467	5	-	.0	.0	70	1	-					
7. Creeping barberry (Mahonia repens)	0.0	0.0	39	1	-										
8. Douglas-fir (Pseudotsuga menziesii)															
9. Douglas rabbitbrush (Chrysothamnus viscidiflorus)	.3	.1	1031	15	-						.1	.0	64	1	-
10. Fourwing saltbush (Atriplex canescens)						.3	.3	263	4	-					
11. Fringed sage (Artemisia frigida)	.6	.3	3449	25		.3	.3	263	4	-					
12. Gambel oak (Quercus gambelii)															
13. Golden currant (Ribes aureum)											2.2	.8	243	7	-
14. Gray horsebrush (Tetradymia canescens)	1.1	.6	1164	24		.4	.4	363	5	-					
15. Greasewood (Sarcobatus vermiculatus)						.3	.3	157	4	-	0.0	0.0	35	1	-
16. Green ephedra (Ephedra viridis)															
17. Martin ceanothus (Ceanothus martini)															
18. Mountain lover (Pachystima myrsinites)															
19. Mountain snowberry (Symphoricarpos oreophilus)	.1	0.0	76	3	-						3.4	1.0	1270	15	-
20. Ocean-spray (Holodiscus dumosus)															
21. Pinyon pine (Pinus edulis)						.5	.5	20	2	-					
22. Plains prickly pear (Opuntia polyacantha)															
23. Red willow (Salix exigua)											.9	.5	40	2	
24. Rocky Mountain maple (Acer glabrum)															
25. Rubber rabbitbrush (Chrysothamnus nauseosus)						.2	.1	250	6	-	3.1	1.1	310	14	-
26. Saskatoon serviceberry (Amelanchier alnifolia)											0.1	0.1	164	2	-
27. Shadscale (Atriplex confertifolia)						3.9	1.0	2343	31	-					
28. True mountain mahogany (Cercocarpus montanus)	.1	.1	14	1	-										
29. Utah juniper (Juniperus osteosperma)															
30. Utah serviceberry (Amelanchier utahensis)	.3	.2	33	4	-						0.4	0.3	88	2	-
31. Water birch (Betula fontinalis)											1.1	1.1	15	2	-
32. Wax currant (Ribes cereum)											.0	.0	14	1	-
33. Whitestem gooseberry (Ribes inerme)	.0	.0	6	1	-						.6	.4	152	3	-
34. Willow (Salix interior)											1.9	1.3	302	5	-
35. Woods rose (Rosa woodsii)											2.1	.7	957	11	-
Totals	3.3		7713			13.7		5603			27.3		6270		
Number of Species	10					13					23				

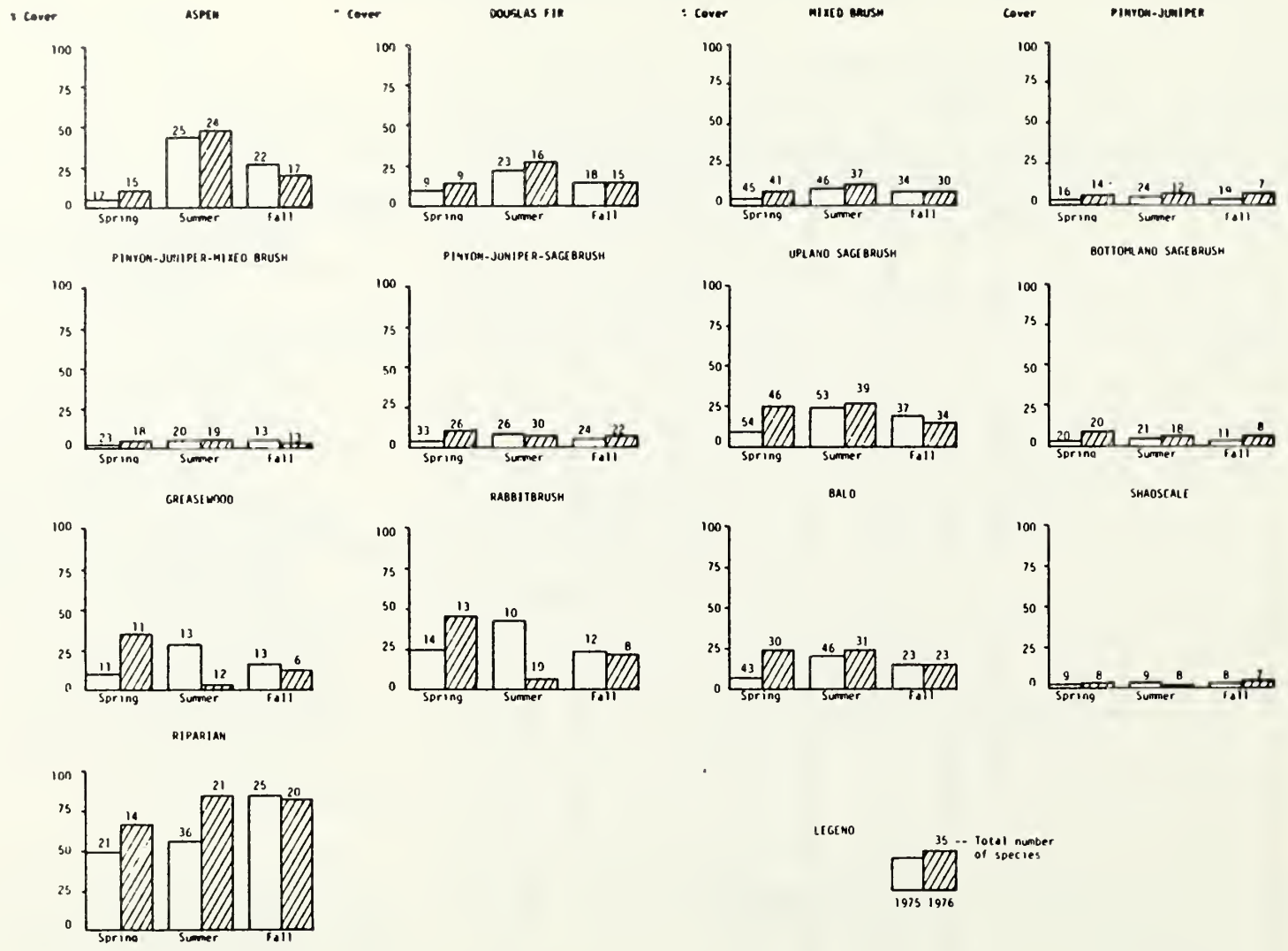


FIGURE J-2

COVER AND NUMBER OF HERBACEOUS SPECIES SAMPLED ON PERMANENT TRANSECTS IN VEGETATION TYPES AND ASSOCIATIONS IDENTIFIED FOR RBOSP, 1975-1976.

TABLE J-3

COVER AND FREQUENCY OF DOMINANT [1] HERBACEOUS SPECIES SAMPLED ON PERMANENT TRANSECTS IN VEGETATION TYPES AND ASSOCIATIONS FOR RBOSP, 1975-1976.

Species	ASPEN [3] (2)						DOUGLAS-FIR (2)						MIXED BRUSH (5)					
	Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Graminoids																		
Big mountain brome						5/55												
Bluestem wheatgrass																		
Crested wheatgrass																		
Elk sedge	3/80		3/50	9/80	6/100	10/95		7/85	10/95		10/95	12/95	2/30	3/28	3/32	5/28	3/30	3/20
Great basin wildrye																		
Indian ricegrass													1/28		1/28		1/22	
Kentucky bluegrass																		
Needle-and-thread															1/10			
Prairie junegrass																		
Quackgrass																		
Sandberg bluegrass														1/14			1/22	
Slender wheatgrass														1/30				
Squirrel tail																		
Forbs																		
Annual stickweed																		
Aster																		
Canada violet			6/30	6/35	3/50													
Eriogonum																		
Fairy candelabra																		
Fendler meadowrue																		
Fineleaf hymenopappus																		
Flowery phlox																		
Fremont goosefoot																		
Fringed sagebrush																		
Goldenweed																		
Hoods phlox																		
Lambsquarter goosefoot																		
Mat penstemon																		
Mountain thermopsis			5/55	9/60	4/100													
Northern bedstraw			3/90															
Stemless goldenweed																		
Stemless hymoxys																		
Sulphur eriogonum														1/22	1/16	2/16		
Summer cypress																		
Sweetroot			5/60	5/75														
Tailcup lupine																		
Tufted milkvetch																		
Peppergrass																		

TABLE J-3 (Continued)

COVER AND FREQUENCY OF DOMINANT [1] HERBACEOUS SPECIES SAMPLED ON PERMANENT TRANSECTS IN VEGETATION TYPES AND ASSOCIATIONS FOR RBOSP, 1975-1976.

Species	UPLAND SAGEBRUSH [2] (4)						BOTTOMLAND SAGEBRUSH [2] (3)						GREASEWOOD (3)						RABBITBRUSH (2)					
	Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Graminoides																								
Big mountain brome																								
Bluestem wheatgrass							.9/20	3.5/20	1.7/20	2.2/17	.5/30	3.3/10												
Crested wheatgrass													2/30											
Elk sedge	1.6/18	1.6/15	2.9/18	6.1/18	6.1/23	4.4/15																		
Great basin wildrye							.6/20	2.1/13	1.6/17	3.0/20	1.7/20								20/95	34/100	37/95	5/100	18/80	23/100
Indian ricegrass																								
Kentucky bluegrass																								
Needle-and-thread			1.0/23																					
Prairie junegrass																								
Quackgrass																								
Sandberg bluegrass	2.1/48	7.5/60	3.4/50	6.4/60	2.2/60	3.7/63																		
Slender wheatgrass																								
Squirrel tail							1.5/33		.8/40	1.2/30	.2/30													
Forbs																								
Annual stickweed													3/57											
Aster																								
Canada violet																								
Eriogonum																								
Fairy candelabra																								
Fendler meadowrue																								
Fineleaf hymenopappus																								
Flowery phlox		2.6/8	1.4/10		1.6/10																			
Fremont goosefoot													2/77				4/90							
Fringed sagebrush																								
Goldenweed																								
Hoods phlox	2.3/30																							
Lambsquarter goosefoot															6/63									
Mat penstemon																								
Mountain thermopsis																								
Northern bedstraw			1.2/23		1.2/23																			
Stemless goldenweed																								
Stemless hymoxys																								
Sulphur eriogonum																								
Summer cypress															9/37		5/33							
Sweetroot																								
Tailcup lupine		3.1/48	4.3/53	3.6/38																				
Tufted milkvetch																								
Pepperweed											.7/30													

TABLE J-3 (Continued)

COVER AND FREQUENCY OF DOMINANT [1] HERBACEOUS SPECIES SAMPLED ON PERMANENT TRANSECTS IN VEGETATION TYPES AND ASSOCIATIONS FOR RBOSP, 1975-1976.

Species	PINYON-JUNIPER [2] (2)						PINYON-JUNIPER MIXED BRUSH 2/ (2)						PINYON-JUNIPER SAGEBRUSH 2/ (3)					
	Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Graminoids																		
Big mountain brome															.9/23			
Bluestem wheatgrass																		
Crested wheatgrass																		
Elk sedge																		
Great basin wildrye																		
Indian ricegrass	.7/65		.6/30		.5/25													
Kentucky bluegrass																		
Needle-and-thread													.4/20		.9/27	1.5/30		1.2/17
Prairie junegrass													.3/40		1.0/30		.3/23	
Quackgrass																		
Sandberg bluegrass		1.4/15	1.2/15	.9/10	.9/25			.6/20		.9/30		.6/25	.6/33	5.4/50	.9/17	2.2/47	1.0/47	1.4/50
Slender wheatgrass	1.0/50	2.6/45	.4/55	2.6/50	.4/35	2.8/50	.2/50	.8/65	.1/30	.9/40	1.3/70	.7/65		2.3/67	1.3/53	1,1/70	1.0/53	1.4/60
Squirrel tail					.4/15							.4/70						
Forbs																		
Annual stickweed																		
Aster																		
Canada violet																		
Eriogonum																		
Fairy candelabra							.2/25											
Fendler meadowrue																		
Fineleaf hymenopappus																		
Flowery phlox																		
Fremont goosefoot																		
Fringed sagebrush																		
Goldenweed			.9/30		1.0/30				.5/25		.5/30							
Hoods phlox							.3/40	1.0/50		.9/40		.3/33						
Lambsquarter goosefoot																		
Mat penstemon																		
Mountain thermopsis																		
Northern bedstraw																		
Stemless goldenweed																		
Stemless hymoxys							.2/10		.6/30		.5/25							
Sulphur eriogonum																		
Summer cypress																		
Sweetroot																		
Tailcup lupine																		
Tufted milkvetch																		
Pepperweed																		

TABLE J-3 (Continued)

COVER AND FREQUENCY OF DOMINANT 1/ HERBACEOUS SPECIES SAMPLED ON PERMANENT TRANSECTS IN VEGETATION TYPES AND ASSOCIATIONS FOR RBOSP, 1975-1976.

	BALD (2)						SHADSCALE 2/ (2)						RIPARIAN (3)					
	Spring		Summer		Fall		Spring		Summer		Fall		Spring		Summer		Fall	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Graminoids																		
Big mountain brome																		
Bluestem wheatgrass																		
Crested wheatgrass																		
Elk sedge																		
Great basin wildrye																32/50	35/57	52/87
Indian ricegrass																		
Kentucky bluegrass															7/24			
Needle-and-thread																		
Prairie junegrass	1/64		2/56															
Quackgrass													36/70	50/97	27/42	34/60	25/47	
Sandberg bluegrass			1/64	7/75	4/95	3/95												
Slender wheatgrass	1/92		2/70	3/75	3/90	3/75												
Squirrel tail								.3/5										
Forbs																		
Annual stickweed																		
Aster	1/34		2/74															
Canada violet																		
Eriogonum							.3/35	1/35	1/40	.7/35	1/40	1/35						
Fairy candelabra																		
Fendler meadowrue																		
Fineleaf hymenopappus			1/20															
Flowery phlox																		
Fremont goosefoot																		
Fringed sagebrush							.1/20			.3/35		2/35						
Goldenweed									.6/20		.4/20							
Hoods phlox																		
Lambsquarter goosefoot																		
Mat penstemon	1/34		2/74															
Mountain thermopsis																		
Northern bedstraw																		
Stemless goldenweed	1/14			3/70		3/45												
Stemless hymoxys			1/68		3/85													
Sulphur eriogonum																		
Summer cypress																		
Sweetroot																		
Tailcup lupine																		
Tufted milkvetch																		
Pepperweed																		

1/ Dominants consist of species comprising first 50% of the total cover
2/ Percentage in tenths provided for species with less than 1% cover
3/ % Cover / Frequency

(ii) Douglas-fir

The Douglas-fir type is characterized by the constant presence of Douglas-fir trees ranging in height from 10 to 20 m (32-65 ft), and a dense and diverse shrub stratum consisting primarily of tall shrub species such as serviceberry, Gambel oak (Quercus gambelii), and chokecherry, and short shrub species such as snowberry and Wood's rose. Douglas-fir stands occur in isolated patches just east of the crest of the Cathedral Bluffs on the western edge of the study area. Stands generally occur at elevations above 2380 m(7800 ft) on steep north- and east-facing slopes (Figure J-1)*. The Douglas-fir type is frequently found adjacent to the aspen type on steeper slopes with shallower soils. The mixed brush type frequently intergrades with the Douglas-fir type on more gentle and on east and south slope exposures. Shrub species common in the mixed brush type are also common in the Douglas-fir understory.

Douglas-fir dominates the tree stratum, providing 50 percent cover, and occurs at densities of approximately 400 individuals per hectare. The shrub stratum in the Douglas-fir type consists of two layers. The upper layer is dominated by Utah and Saskatoon serviceberry, which occur in large clones, and ranges in height to 3 m (10 ft). The lower layer is dominated by mountain snowberry, which occurs at high densities and is usually less than 1 m (3 ft) in height. Together, the three species provided 64 percent of the total cover, and 47 percent of the total density for the shrub stratum (Table J-2). The high density of Douglas-fir seedlings and saplings makes it an important species in the shrub stratum.

Herbaceous species density and total cover is lower than in aspen stands at comparable elevations. Elk sedge was the dominant species during all sampling periods, providing relatively constant cover of approximately 10 percent throughout the year (Table J-3). Maximum cover and species density occurred during July, when 23 species provided 23 percent total cover (Figure J-2).

* See Volume II

Although occupying small areas, the aspen type and the Douglas-fir types are the most structurally diverse types on the study area because they contain a tall tree stratum as well as a multi-level shrub stratum. The comparatively more moist habitats of the aspen and Douglas-fir types support several species of plants not found elsewhere in the study area. Some examples are Colorado columbine, clematis, meadow rue, and mountain thermopsis.

Aspen and Douglas-fir will not be disturbed by the MDP activities.

(iii) Mixed brush

The mixed brush type is characterized by the tall, 1-3 m (3-10 ft), life form of three species, Gambel oak, Utah serviceberry, and true mountain mahogany (Cercocarpus montanus). Shorter shrubs, 1 m (3 ft), consisting of big sagebrush and snowberry coexist with the taller species.

The mixed brush type occurs as a broad expanse across middle and upper elevations, 2100-2550 m (7000-8500 ft), of the study area (Figure J-1)*. At its upper limits it intergrades with the aspen and Douglas-fir types on steep slopes near the summit of Cathedral Bluffs. At the lower limits it intergrades with upland sagebrush areas on gentle slopes, and the pinyon-juniper type on steeper slopes above drainages.

The shrub stratum shows a wide range of diversity with up to 21 species, and is divided into a tall shrub layer dominated by Utah serviceberry (47 percent relative cover) and a low shrub layer dominated by big sagebrush (Artemisia tridentata), or mountain snowberry (Table J-2). Gambel oak increases in importance in the wetter stands and true mountain mahogany increases in importance on drier slopes or shale outcroppings.

Herbaceous cover was nearly constant (approximately 10 percent) over the growing season in quadrats sampled in this type. Elk sedge was the dominant species throughout all seasons during both years, contributing 30 to 50 percent relative cover (Table J-3). Species density was among the highest for any

* See Volume II

type on the study area (Figure J-2), but individual species contributed only small fractions of the total cover (Table J-3). Total species diversity in permanent quadrats varied from over 40 during the spring during both years to 46 in the summer of 1975 and 37 in 1976, declining to over 30 for both years during the fall (Figure J-2).

(iv) Pinyon-juniper

The most extensive vegetation type in the Piceance Basin and the study area is dominated by pinyon pine and Utah juniper, together ranging in height from 3-7 m (10-22 ft). The type occurs as a broad expanse across the middle and lower elevations of the study area, 1950-2250 m (6500-7500 ft). It occurs on both steep and gentle slopes, and at all slope aspects (Figure J-1)*. The pinyon-juniper type is completely overlapped by the sagebrush type and the two types intergrade at all elevations within the study area. The pinyon-juniper type intergrades with the mixed brush type on steep north- and south-facing slopes along major drainages. In the study area the pinyon-juniper type was sampled over an elevational range of 1950-2300 m (6500 and 7600 ft).

The tree canopy of pinyon pine and Utah juniper in the study area is usually very open (approximately 20 percent total cover), with the individual trees well spaced (250 individuals/ha) (RBOSP 1976). The shrub stratum of the pinyon-juniper type is diverse (20 species) but maintains a low average cover. The most common shrub within the type is big sagebrush. Seedlings and saplings of pinyon are common in the shrub stratum. Utah serviceberry is moderately frequent in the type and maintains a comparatively high cover (Table J-2).

The herbaceous cover for all three pinyon-juniper associations is low (2-6 percent) (Figure J-2) but the total number of species encountered varied from 7 to 33. The dominant herbaceous species are Sandberg bluegrass, slender wheatgrass, and Hoods phlox.

Because of the broad range of the pinyon-juniper type over the study area, and the varied terrain that it occupies, the type was divided into three

* See Volume II

variants or associations based on composition and cover criteria in the shrub stratum. The characteristics of each association are listed below.

Pinyon-Juniper Mixed Brush

- The occurrence of a shrub stratum with greater than 7 percent cover; of this shrub cover, big sagebrush cannot contribute more than 50 percent of the total cover;
- Shrub species which are characteristically members of the mixed brush type (serviceberry, mountain mahogany, bitterbrush); composition not limited to these species.

Pinyon-Juniper Sagebrush

- The occurrence of a shrub stratum with 6 percent or greater cover;
- Strong dominance of the shrub stratum by Artemisia tridentata (greater than 50 percent of the total cover);
- The occurrence of other species commonly associated with a big sagebrush (green rabbitbrush, bitterbrush).

Pinyon-Juniper Woodland

- Shrub stratum with less than 6 percent cover.

(v) Sagebrush

The sagebrush type on the study area is characterized by the constant presence, high cover, and high density of big sagebrush in the shrub stratum and by an herbaceous stratum with high species diversity, but generally low cover. Mature sized trees are generally absent from this type.

The sagebrush type occurs over a wider elevation range, 1925-2575 m (6420-8550 ft), than any other type found on the study area (Figure J-1)*, and generally occurs on gentle slopes. The sagebrush type intergrades with the pinyon-juniper type at lower elevations along drainages, and on uplands along the ridges above

* See Volume II

the major drainages. Boundaries between sagebrush and pinyon-juniper types are frequently very distinct along transitions between alluvial bottomland sagebrush stands and pinyon-juniper stands occurring on steep shale outcrops. Transitions are often very gradual between the two types in areas where soil depth does not vary sharply. Big sagebrush is a frequent component of the understory in the pinyon-juniper type, and decreases in abundance with increasing density and cover of pinyon and Utah juniper. The sagebrush type also intergrades gradually with the mixed brush type on gentle upland slopes. The sagebrush type includes upland sagebrush, bottomland sagebrush, rabbitbrush, and greasewood associations.

Upland Sagebrush - Upland sagebrush occupies a broad elevational range over the study area, occurring from nearly level areas on the lower elevations on 84 Mesa up to the crest of the Cathedral Bluffs, 2550 m (8500 ft). Upland sagebrush frequently occurs as isolated stands (inclusions) within the pinyon-juniper type where sagebrush occupies areas of deeper soils, and within the mixed brush type where sagebrush occupies exposed ridgelines (Figure J-1).*

Of 23 species recorded in the shrub station, big sagebrush was the dominant species, contributing 81 percent relative cover and 60 percent relative density on the transects sampled (Table J-2). Other common associates were Douglas rabbitbrush (2 percent cover) and mountain snowberry (2 percent cover).

The herbaceous stratum is diverse (up to 60 species) (RBOSP 1976) and dominance is shared by several species, particularly Sandberg bluegrass and Hoods phlox at lower elevations, and elk sedge at higher elevations. Herbaceous cover ranged from 10-25 percent in the spring, remaining at approximately 25 percent during the summer, and declining to less than 20 percent in the fall (Figure J-2).

Bottomland Sagebrush - The bottomland sagebrush association is distributed along the bottoms of the major drainages of the study area where it occurs on alluvial material. This association is commonly bounded by the upland sagebrush association on slopes leading into the valley floor.

* See Volume II

Transitions in shrub height and density are frequently sharp between the two associations where the shallow soils of side slopes meet the deeper soils of the bottomlands.

Total shrub stratum cover (46 percent) and density (17,900 individuals/ha) are the highest for any of the four sagebrush associations (Table J-2). Although 15 species of shrubs were recorded in the shrub stratum, big sagebrush contributed over 70 percent of the cover, and over 50 percent of the density. Other common species were Douglas and rubber rabbitbrush. Small shrub seedlings observed in undisturbed bottomland stands were almost entirely big sagebrush.

The herbaceous stratum consists primarily of perennial grass species and several annual forbs and has a very low cover as compared to the upland sagebrush association (Table J-3). Predominant species at all seasons were western wheatgrass (Agropyron smithii), Great Basin wildrye (Elymus cinereus), and squirreltail (Sitanion longifolia). Herbaceous cover was uniformly low throughout the growing season, not exceeding 10 percent during the spring and summer and declining to less than 5 percent during the fall. Maximum species diversity was recorded during the spring (20 species), declining to approximately 10 species by fall (Figure J-2).

Greasewood - The greasewood association is characterized by the occurrence of greasewood in excess of 50 percent of the total shrub cover on a site. The greasewood association occurs as small isolated patches within the bottomland sagebrush association, primarily along the Box Elder Gulch and Duck Creek drainages (Figure J-1)*. Greasewood is widely recognized as an indicator of saline-sodic soils, and appears to predominate on areas which have high water tables (Harrington 1964).

The shrub stratum of greasewood stands was found to be the lease diverse of any association or type on the study area, with only 4 species of shrubs sampled on transects. Shrub cover is comparable to that found in adjacent bottomland sagebrush stands. Greasewood is the dominant species, contributing

* See Volume II

over 60 percent of the cover, and nearly 50 percent of the total density. Big sagebrush and rubber rabbitbrush are also common within this association (Table J-2).

The herbaceous stratum in the greasewood association consists primarily of both annual forbs and perennial grasses. Based on an average of the seasonal cover for the two year study period, cover ranged around 20 percent for both spring and summer when annual species such as summer cypress and goosefoot reach their maximum development. Cover then declined to around 15 percent during the fall (Figure J-2). Cover values for spring 1976 were approximately twice those for 1975 (Figure J-2), and values for summer of 1975 were nearly 6 times greater than those for summer of 1976. Fall cover values for the two years were similar, although fewer species were recorded in fall 1976.

Rabbitbrush - The rabbitbrush association is characterized by the dominance of rabbitbrush in the shrub stratum, which provides approximately 90 percent relative cover. Rabbitbrush stands in the study area range from open, consisting of scattered shrubs and clumps of Great Basin wildrye, to closed stands consisting primarily of annual species.

The rabbitbrush association represents a secondary successional stage within the bottomland sagebrush association. Most of the stands sampled in the study area occupy abandoned agricultural lands along drainages or show evidence of removal of big sagebrush by burning, defoliation, or mechanical means.

The rabbitbrush association consists primarily of Great Basin wildrye, goosefoot, and cheatgrass. Herbaceous stratum diversity was relatively constant (approximately 10 species) over all seasons during both years. Herbaceous stratum cover varied from as high as 50 percent in the spring and summer, to slightly more than 25 percent in the fall (Figure J-2).

(vi) Bald

The bald type is characterized by the near absense of tree and shrub strata, and a diverse herbaceous cover consisting of perennial forbs and grasses which occur along the summit of Cathedral Bluffs, and on exposed ridges at lower elevations. The bald type ranges in elevation from 2,170-2,565 m (7230-8550 ft), and occurs almost exclusively on west slope aspects facing the prevailing wind (Figure J-1)*.

Shrub species occur sparingly on the bald type (1.5 percent cover), and are usually of very low stature. Utah serviceberry provided the most cover, but was generally restricted to more protected sites. Low stature shrubs characteristic of this type were green rabbitbrush and horsebrush (Table J-2).

The diverse (60 species) herbaceous stratum consisted of low grass and forb species that frequently form a carpet-like mat. Total cover for this type is not highly variable over the growing season and is consistently around 20 percent (Figure J-2). Dominance during all sampling periods was shared by several species of perennial grasses, particularly Sandberg bluegrass, slender wheatgrass, and prairie junegrass. The bald vegetation type will not be disturbed by MDP activities.

(vii) Shadscale

The shadscale type occurs over a narrow elevational range, 1938-2045 m (6460-6810 ft), in narrow bands on steep, generally south facing slopes adjacent to major drainages within the study area (Figure J-1). The shadscale type is an edaphically and topographically determined type which is limited to steep slopes of shale outcrops on the study area. The probable higher salinity of these shale outcrops may contribute to the predominance of shadscale on these sites.

Thirteen species contribute a total shrub cover of 14 percent (Table J-2). Shadscale shares dominance with three shrubs from the sagebrush type, big sagebrush, Douglas rabbitbrush and rubber rabbitbrush, indicating its close

* See Volume II

relationship to the sagebrush type. The herbaceous stratum is very poorly developed, with less than 5 percent total cover at all seasons, and very low (less than 10) species diversity (Figure J-2). Eriogonum and fringed sagewort provided the greatest cover at all sampling periods.

(viii) Riparian

The riparian type in the study area consists of three different environments: small springs in open alluvial bottomlands that have been converted to pastureland occupied by common pasture weeds (e.g., Stake Springs), hillside springs and seeps along the bottom of steep draws which are not heavily grazed and contain several unusual species for the Piceance Basin (e.g., Cottonwood Spring), and drainages of intermittent streams that contain species characteristic of the bottomland sagebrush association, (e.g., Box Elder and Water Gulches) (Figure J-1)*.

Tree species were not frequent in this type (Table J-2). Aspen appeared on one transect sampled at a high elevation. A few large individuals of narrowleaf cottonwood (Populus angustifolia) were observed at Cottonwood Spring.

The greatest number (23) of shrub species of one type on the study area were found in riparian areas. Dominants in the shrub stratum, big sagebrush and rubber rabbitbrush are found along the drainageways of intermittent streams. In a few isolated areas (Cottonwood Spring, Duck Creek), more characteristic riparian species were found: water birch (Betula fontinalis), willow (Salix exigua and Salix interior), and red osier dogwood (Swida sericea). In wet pastures, shrubs are largely absent except for rubber rabbitbrush, which occurs around the fringes. Total shrub cover for the type ranges from a low of 2 percent cover on wet, heavily grazed pasture sites to 25 percent cover for transects sampled in hillside springs and along intermittent streams.

Permanent herbaceous quadrats are located in wet pasture sites. As a result, the high total cover (50 to 80 percent) during all seasons reflects the very moist growing conditions (Figure J-2). Quackgrass (Agropyron repens), Kentucky

* See Volume II

bluegrass (Poa pratensis) and common dandelion (Taraxacum officinale) were common constituents of wet pastures (Table J-3).

Riparian habitat will not be affected by MDP construction activities.

b. Relationship of the Dominant Vegetation Types Existing on Tract C-a to Soil Types

The relationship between the existing vegetation and soil types on Tract C-a is presented in Table J-4. Detailed maps of the distribution of vegetation (Figure C-4)* and soils (Figure C-5)* occuring in the areas to be disturbed are presented in Exhibit C. A comparison of these two figures indicates the relationship described in Table J-4.

TABLE J-4

RELATIONSHIP OF THE SOIL TYPES TO THE DOMINAT VEGETATION ON TRACT C-a

Soil Type	% of Tract	Dominant Vegetation Types
Rentsac Series	46	Pinyon-juniper, sagebrush mixed-brush
Rentsac-Piceance complex	27	Pinyon-juniper, sagebrush
Rock Outcrop-Torriorthent Complex	11	Shadscale, pinyon-juniper
Glendive Series	9	Sagebrush, rabbitbrush, greasewood
Redcreek-Rentsac Complex	6	Pinyon-juniper, sagebrush
Rivra, Yamac & Havre series	1	Sagebrush, rabbitbrush, greasewood

Sagebrush - Sagebrush vegetation is found on moderately alkaline, nonsaline, and nonsodic soils. Sagebrush occurs on deep alluvial soils in valley bottoms (Glendive series), on mixtures of moderately deep aeolian and residual soils (Rentsac and Piceance series), and on gently sloping uplands (Yamac series).

Pinyon-Juniper - Pinyon-juniper vegetation type occurs on nonsaline, non-sodic, and moderately alkaline soils. The pinyon-juniper type is found primarily on the Rentsac soil series which are shallow, well-drained soils formed from sandstone. The Rentsac soils, and hence pinyon-juniper, occur primarily on ridges and on drainage side slopes.

* See Volume II

The pinyon-juniper type also occurs on extremely shallow soils, sandstone cliffs, or siltstone outcroppings (Rock Outcrop-Torriorthent complex) in the study area.

Mixed Brush - Mixed brush exhibits its best development on deep, sandy loam soils at higher elevations, but extensive mixed brush areas occur on steep north-facing slopes on shallow soils above shale outcroppings at lower elevations. Soils supporting mixed brush have a high organic matter content but low pH, electrical conductivity and ESP.

Greasewood - Greasewood dominates on saline, sodic, and strongly alkaline alluvial soils on gentle slopes or along drainages. Greasewood appears to predominate on areas which have high water tables (Harrington 1964).

Rabbitbrush - Rabbitbrush occurs on bottomland soils (Glendive series) where sagebrush has been eliminated. See sagebrush above for additional details.

Shadscale - The shadscale type occurs in narrow bands on steep, generally south-facing slopes adjacent to major drainages within the study area. It occurs on outcrops or very shallow soils derived from sandstone cliffs or platy siltstone outcrops (Rock Outcrop-Torriorthent complex). Soils of the shadscale vegetation type are nonsaline and nonsodic, but the soluble salt electrical conductivity and the ESP are relatively high when compared to the soils of other vegetative types.

c. Productivity of the Vegetation Types on Tract C-a

Agriculture occupies less than 1 percent of the study area and occurs along Yellow Creek, Ryan Gulch, Black Sulphur Creek, and Stake Springs Draw. These areas are used for hay production. RBOSP MDP activities will not disturb any of these areas and therefore average annual production has not been estimated.

Annual production was estimated in the fall of 1975 for the dominant vegetation types. Results of this study (Table J-5) indicate that sagebrush is the most productive of the vegetation types occurring in the study area.

Three Bureau of Land Management (BLM) grazing allotments exist in the vicinity of Tract C-a. The Reagle and Square S Allotments have been placed under allotment management plans (AMP). The BLM is presently preparing an AMP for the Box Elder allotment. The northwest 1/2 of Tract C-a is in the Box Elder Allotment and the remaining portion is in the Square S Allotment. Since cattle range freely on and off the Tract within the allotments, actual stocking rates in animal unit months (AUMs) have not been calculated for Tract C-a. The BLM estimates the carrying capacity of Tract C-a to be 600 AUMs (personal communication K. Russell, BLM, Meeker, CO, November 1976).

TABLE J-5

FORAGE PRODUCTION AND UTILIZATION ESTIMATES [1/]
OBTAINED IN THE FALL 1975 ON AND NEAR TRACT C-a

Tract C-a Vegetation Type	Dry Weight Production lbs/A (Kg/ha)	No. of Samples	Standard Error lbs/A (Kg/ha)	Utilized Forage lbs/A (Kg/ha)	Percent Utilization [2/]
Pinyon-Juniper	100.5 (113.6)	210	6.85 (7.74)	46.8 (52.9)	31.8
Sagebrush	268.7 (303.6)	200	30.65 (34.63)	21.8 (24.6)	7.5
Mixed Brush	206.6 (233.5)	130	11.19 (12.64)	128.0 (144.6)	38.2
Bald	135.2 (152.8)	100	12.09 (13.60	91.8 (103.7)	40.4

1/ Table values have been adjusted to correct for minor errors in results reported in Second Annual Report (RBOSP, 1976)

2/ Percent utilization $= \dfrac{\bar{X} \text{ cage plot field wt} - \bar{X} \text{ occular plot field wt.}}{\bar{X} \text{ cage plot field wt.}} \times 100$

LITERATURE CITED

Harrington, H. D. 1964. Manual of the plants of Colorado. Swallow Press Inc., Chicago. 666 p.

RBOSP. 1976. Terrestrial Annual Report. Gulf-Standard. Denver, CO.

RBOSP. 1977. Progress Report 10. Gulf-Standard. Denver, CO.

USDI. 1975. Report on endangered and threatened plant species of the United States. GPO, Washington, D.C. 200 p.

ATTACHMENT J-1

SPECIES OF PLANTS OBSERVED IN THE VICINITY OF TRACT C-a
DURING 1974 - 1975

Abbrev.	Species
	TREES
Juos[1/]	Juniperus osteosperma (Torr.) Little;[2/] (Pinaceae),[3/] Phan,[4/] Utah juniper, (V) [5/]
Pied	Pinus edulis Engelm.; (Pinaceae), Phan, pinyon pine
Poan	Populus angustifolia James; (Salicaceae), Phan, narrowleaf cottonwood, (V)
Potr	Populus tremuloides Michx.; (Salicaceae), Phan, quaking aspen
Psme	Pseudotsuga menziesii (Mirbel) Franco; (Pinaceae), Phan, Douglas fir
	SHRUBS
Acgl	Acer glabrum Torr.; (Aceraceae), Phan, Rocky Mountain maple, (V)
AMELA	Amelanchier sp.
Amal	Amelanchier alnifolia Nutt.; (Rosaceae), Phan, Saskatoon serviceberry, (V)
Amut	Amelanchier utahensis Koehne; (Rosaceae), Phan, Utah serviceberry, (V)
Arfr	Artemisia frigida Willd.; (Compositae), Cham, fringed sagebrush, (V)
Artr	Artemisia tridentata Nutt.; (Compositae), Phan, Cham, big sagebrush, (V)
Atca	Atriplex canescens (Pursh) Nutt.; (Chenopodiaceae) Cham, fourwing saltbrush, (V)
Atco	Atriplex confertifolia (Torr. & Fremont) S. Wats.; (Chenopodiaceae), Cham, shadscale, (V)
	Berberis repens; See Mahonia repens

* Footnotes listed at end of species list.

Abbrev.	Species
	SHRUBS (Cont.)
Befo	Betula fontinalis Sarg.; (Betulaceae), Phan, water birch, (V)
	Betula occidentalis; See Betula fontinalis
Cema	Ceanothus martini M.E. Jones; (Rhamnaceae), Cham, Martin ceanothus, (V)
Cemo	Cercocarpus montanus Raf.; (Rosaceae), Phan, true mountain mahogany, (V)
CHRYS	Chrysothamnus sp.
Chde	Chrysothamnus depressus Nutt. (Compositae), Cham, dwarf rabbitbrush
Chna	Chrysothamnus nauseosus (Pall.) Britt, in Britt & Brown (Compositae), Phan, rubber rabbitbrush, (V)
Chvi	Chrysothamnus viscidiflorus (Hook.) Nutt, (Compositae) Cham, Douglas rabbitbrush, (V)
	Cornus stolonifera; See Swida sericea
Epvi	Ephedra viridis Coville; (Ephedraceae), Cham, green ephedra
Eula	Eurotia lanata (Pursh) Moquin; (Chenopodiaceae), Cham, common winterfat, (V)
Gusa	Gutierrezia sarothrae (Pursh) Britt. & Rusby; (Compositae), Cham, broom snakeweed
Hodu	Holodiscus dumosus (Nutt.) Heller; (Rosaceae), Cham, bush ocean-spray, (V)
Mare	Mahonia repens (Lindl.) G. Don; (Berberidaceae), Cham, creeping barberry, (V)
Opfr	Opuntia fragilis (Nutt.) Haw.; (Cactaceae), Succ, brittle pricklypear
Oppo	Opuntia polyacantha Haw.; (Cactaceae), Succ, plains pricklypear

Abbrev.	Species
	SHRUBS (Cont.)
Pamy	Pachystima myrsinites (Pursh) Raf.; (Celastraceae), Cham, myrtle pachystima, (V)
Puvim	Prunus virginiana var. melanocarpa (A. Nels.) Sarg.; (Rosaceae), Phan, black common chokecherry
Putr	Purshia tridentata (Pursh) D.C.; (Rosaceae), Cham, antelope bitterbrush, (V)
Quga	Quercus gambelii Nutt.; (Fagaceae), Phan, Gambel oak, (V)
RIBES	Ribes sp.
Riau	Ribes aureum Pursh; (Saxifragaceae), Cham, golden current, (V)
Rice	Ribes cereum Dougl.; (Saxifragaceae), Cham, wax current, (V)
Riin	Ribes inerme Rydb.; (Saxifragaceae), Cham, whitestem gooseberry, (V)
ROSA	Rosa sp.
Rowo	Rosa woodsii Lindl.; (Rosaceae), Cham, Wood's rose
Saex	Salix exigua Nutt.; (Salicaceae), Cham, willow, (V)
Sain	Salix interior Rowlee; (Salicaceae), Cham, willow, (V)
Saco	Sambucus coerulea Raf.; (Caprifoliaceae), Cham, blueberry elder, (V)
Save	Sarcobatus vermiculatus (Hook.) Torr.; (Chenopodiaceae), Cham, black greasewood, (V)
Sosc	Sorbus scopulina Greene; (Rosaceae), Cham, Greenes mountain-ash, (V)
wse	Swida sericea (L.) Holub; (Cornaceae), Cham, redosier dogwood, (V)

Abbrev.	Species
	SHRUBS (Cont.)
Syor	Symphoricarpos oreophilus A. Gray; (Caprifoliaceae), Cham, mountain snowberry (V)
Teca	Tetradymia canescens D.C.; (Compositae), Cham, gray horsebrush, (V)
	HERBACEOUS (NON-GRASSLIKE)
Acla	Achillea lanulosa Nutt.; (Compositae) Hemi, western yarrow, (N) 6/ (V)
Agur	Agastache urticifolia Kuntze; (Labiatae), Hemi, nettleleaf giant-hyssop, (N) (V)
AGOSE	Agoseris sp.
Agau	Agoseris aurantiaca (Hook.) Greene; (Compositae) Hemi, orange agoseris, (N) (V)
Aggl	Agoseris glauca (Pursh) Raf.; (Compositae), Hemi, pale agoseris, (N) (V)
Alte 2	Allium textile Nels. & Macbr.; (Liliaceae), Cryp, textile onion, (N) (V)
AMBRO	Ambrosia sp. (L.); (Compositae) Ther, ragweed, (N)
Anse	Androsace septentrionalis L.; (Primulaceae), Ther, rock-jasmine, (N) (V)
ANGEL	Angelica sp.
Anam	Angelica amola A. Nels; (Umbelliferae), Hemi, Angelica, (N) (V)
Anpi	Angelica pinnata S. Wats; (Umbelliferae), Hemi, small-leaf angelica, (N) (V)
ANTEN	Antennaria sp.
Anmi	Antennaria microphylla Rydb.; (Compositae), dioecious, Hemi, rose pussytoes (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Anpu	Antennaria pulcherrima (Hook.) Green; (Compositae), dioecious, Hemi, showy pussytoes, (N) (V)
Anro	Antennaria rosea Green; (Compositae), dioecious, Hemi, rose pussytoes (N) (V)
Aqba	Aquilegia barnebyi Munz; (Ranunculaceae), Hemi, columbine, (Rare--endemic to Green River shale deposits), (N) (V)
Aqca	Aquilegia caerulea James; (Ranunculaceae), Hemi, Colorado columbine, (Protected by Colorado State Law) (N) (V)
ARABI	Arabis sp.
Ardi 3	Arabis divaricarpa A. Nels.; (Cruciferae), Hemi, rockcress, (N) (V)
Ardr	Arabis drummondi A. Gray; (Cruciferae), Hemi, Drummond rockcress, (N) (V)
Arfe 4	Arabis fendleri (Wats.) Greene; (Cruciferae), Hemi, Fendler rockcress, (N) (V)
Arfes	Arabis fendleri var. spatifolia (Rydb.) Rollins; (Cruciferae), Hemi, rockcress, (N) (V)
ARENA	Arenaria sp.
Area	Arenaria eastwoodiae Rydb.; (Caryophyllaceae), Hemi, sandwort, (N) (V)
Arfe	Arenaria fendleri A. Gray; (Caryophyllaceae), Hemi, Fendler sandwort, (N) (V)
ARTEM	Artemisia sp.
Ardr	Artemisia dracunculus L.; (Compositae), Hemi, Tarragon, (N) (V)
Arlu	Artemisia ludoviciana Nutt.; (Compositae), Hemi, Louisiana sagebrush, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Ascr	Asclepias cryptoceras S. Wats.; (Asclepidaceae), Hemi, milkweed, (N) (V)
ASTER	Aster sp.
Asar 6	Aster arenosus Blake; (Compositae), Hemi, aster, (N) (V)
Asca 4	Aster campestris Nutt.; (Compositae), Hemi, aster, (N) (V)
ASTRA	Astragalus sp.
Asch	Astragalus chamaeleuce A. Gray; (Leguminosae), Hemi, milkvetch, (N) (V)
Asdi	Astragalus diversifolius A. Gray; (Leguminosae), Hemi, milkvetch, (N) (V)
Aslu	Astragalus lutosus M.E. Jones; (Leguminosae), Hemi, milkvetch, (threatened and endangered--endemic to Green River shale deposits), (N) (V)
Aspu	Astragalus purshii Dougl. ex. Hook; (Leguminosae), Hemi, Pursh locoweed, (N) (V)
Assp 3	Astragalus spatulatus Sheld.; (Leguminosae), Hemi, tufted milkvetch, (N) (V)
Aste 3	Astragalus tenellus Pursh; (Leguminosae), Hemi, loose flower milkvetch, (N) (V)
Basa	Balsamorhiza sagittata (Pursh) Nutt.; (Compositae), Hemi, arrowleaf balsam root, (N) (V)
BORAG	Boraginaceae
CALOC	Calochortus sp.
Canu	Calochortus nuttallii Torr.; (Liliaceae), Cryp, segolily mariposa, (N) (V)
Cagu	Calochortus gunnisonii S. Wats.; (Liliaceae), Cryp, (N)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Cabu	Capsella bursa-pastoris (L.) Medic.; (Cruciferae), Ther, shepherds-purse, (I)
Cach 3	Castilleja chromosa A. Nels.; (Scrophulariaceae), Hemi, Indian paintbrush, (N) (V)
Cali	Castilleja linariaefolia Benth in D.C.; (Scrophulariaceae), Hemi, Wyoming painted cup (N) (V)
CHAEN	Chaenactis sp.
Chdo	Chaenactis douglasii (Hook) Hook & Arn.; (Compositae), Hemi, Douglas chaenactis, (N) (V)
CHENO	Chenopodium sp.
Chal	Chenopodium album L.; (Chenopodiaceae), Ther, lambsquarter goosefoot, (I) (V)
Chfr 2	Chenopodium fremontii S. Wats.; (Chenopodiaceae), Ther, Fremont goosefoot, (N) (V)
	Chenopodium gigantospermum; See Chenopodium hybridum
Chgi	Chenopodium hybridum (L.); (Chenopodiaceae), Ther, mapleleaf goosefoot, (origin uncertain), (V)
Chle	Chenopodium leptophyllum Nutt.; (Chenopodiaceae), Ther, slimleaf goosefoot, (N) (V)
Chte	Chorispora tenella D.C.; (Cruciferae), Ther, chorispora, (I) (V)
CIRSI	Cirsium sp.
Ciar 2	Cirsium arvense (L.) Scop.; (Compositae), Hemi, Canada thistle, (I) (V)
	Cirsium lanceolatum; See Cirsium vulgare

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Ciun	Cirsium undulatum (Nutt.) Spreng.; (Compositae), Hemi, wavyleaf thistle, (N) (V)
Civu	Cirsium vulgare (Savi) Tenore; (Compositae), Hemi, bull thistle, (I) (V)
Clco	Clematis columbiana (Nutt) T.& G.; (Ranunculaceae), Hemi, (N)
Clhi	Clematis hirsutissima Pursh; (Ranunculaceae), Hemi, Douglas clematis, (N) (V)
Clps	Clematis pseudoalpina (Kuntze) A. Nels. in Coult. & Nels; (Ranunculaceae), Hemi, (N) (V)
Copa 2	Collinsia parviflora Dougl. in Lindl.; (Scrophulariaceae), Ther, little flower collinsia, (N) (V)
Coli	Collomia linearis Nutt.; (Polemoniaceae), Ther, slenderleaf collomia, (N) (V)
Copa	Comandra umbellata ssp. pallida (A. DC.) Piehl; (Santalaceae), Hemi, bastard toadflax, (N) (V)
COMPO	Compositae
Coau	Corydalis aurea Willd.; (Fumariaceae), Ther, golden corydalis, (N) (V)
CREPI	Crepis sp.
Crac	Crepis acuminata Nutt.; (Compositae), Hemi, tapertip hawksbeard, (N) (V)
Croc	Crepis occidentalis Nutt.; (Compositae), Hemi, western hawksbeard, (N) (V)
CRUCI	Cruciferae
CRYPT	Cryptantha sp.

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Crse	Cryptantha sericea (A. Gray) Payson; (Boraginaceae), Hemi, (N) (V)
CYMOP	Cymopterus sp.
Cyac	Cymopterus acaulis (Pursh) Raf.; (Umbelliferae), Cryp, (N) (V)
Cyfe	Cymopterus fendleri A. Gray; (Umbelliferae), Cryp, Chimaya, (N) (V)
DELPH	Delphinium sp.
Dene	Delphinium nelsonii Green; (Ranunculaceae), Hemi, Menzies larkspur, (N) (V)
DESCU	Descurainia sp.
Depi	Descurainia pinnata (Walt.) Britt; (Cruciferae), Ther, pinnate tanseymustard, (N)
Deri	Descurainia richardsonii (Sweet) O.E. Schulz; (Cruciferae), Ther, Richardson tanseymustard, (N) (V)
Epad	Epilobium adenocaulon Hausskn.; (Onograceae), Hemi, sticky willowweed, (N) (V)
EQUIS	Equisetum sp.
Eqla	Equisetum laevigatum A. Br.; (Equisetaceae), Cryp, smooth horsetail, (N) (V)
ERIGE	Erigeron sp.
Erea	Erigeron eatonii A. Gray; (Compositae), Hemi, Eaton fleabane, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Erpu 2	Erigeron pumilus Nutt.; (Compositae), Hemi, low fleabane, (N) (V)
Ersp	Erigeron speciosus (Lindl.) DC.; (Compositae), Hemi, Oregon fleabane
ERIOG	Eriogonum sp.
Eral	Eriogonum alatum Torr.; (Polygonaceae), Hemi, wing eriogonum, (N) (V)
Ervi	Eriogonum densum Greene; (Polygonaceae), Hemi, broom eriogonum, (N) (V)
Erlo	Eriogonum lonchophyllum T. & G.; (Polygonaceae), Hemi, eriogonum, (N) (V)
Erov	Eriogonum ovalifolium Nutt.; (Polygonaceae), Hemi, cushion eriogonum, (N) (V)
Erum	Eriogonum umbellatum Nutt.; (Polygonaceae), Hemi, sulfur eriogonum, (N) (V)
Erar 6	Erysimum asperum (Nutt.) DC.; (Polygonaceae), Hemi, plains erysimum, (N) (V)
EUPHO	Euphorbia sp.
Eufe	Euphorbia fendleri T. & G.; (Euphorbiaceae), Hemi, Fendler euphorbia, (N) (V)
Euro	Euphorbia robusta (Engelm.) Small; (Euphorbiaceae), Hemi, robust euphorbia, (N) (V)
FRAGA	Fragaria sp.
Frsp	Frasera speciosa Douglas; (Gentianaceae), Hemi, showy frasera, (N) (V)
Frat	Fritillaria atropurpurea Nutt.; (Liliaceae), Cryp, purplespot fritillaria, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Gabo	Galium boreale L.; (Rubiaceae), Hemi, northern bedstraw, (N) (V)
Geri	Geranium richardsonii Fisch. & Trautv.; (Geraniaceae), Hemi, Richardson geranium, (N) (V)
	Gilia spp ; See Ipomopsis sp..
Gymu	Gymnolomia multiflora (Nutt.)Benth & Hook.; (Compositae), Hemi, showy goldeneye, (N) (V)
Hafl	Hackelia floribunda (Lehm.) Johnston; (Boraginaceae), Hemi stickseed, (N) (V)
HAPLO	Haplopappus sp.
Haac	Haplopappus acaulis (Nutt.) A. Gray; (Compositae), Hemi, stemless goldenweed, (N) (V)
Hanu	Haplopappus nuttallii T. & G.; (Compositae), Hemi, goldenweed, (N) (V)
HEDYS	Hedysarum sp.
Hebo	Hedysarum boreale Nutt.; (Leguminosae), Hemi, northern sweetvetch, (N) (V)
Heun	Helianthella uniflora (Nutt.) T.&G.; (Compositae), Hemi, oneflower helianthella, (N) (V)
Hela	Heracleum lanatum Michx.; (Umbelliferae), Hemi, common cowparsnip, (N) (V)
Hepa	Heuchera parviflora Nutt. ex. T. & G.; (Saxifragaceae), Hemi, littleleaf alumroot, (N) (V)
Hyfi	Hymenopappus filifolius Hook.; (Compositae), Hemi, fineleaf hymenopappus, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
HYMEN	Hymenoxys sp.
Hyac	Hymenoxys acaulis (Pursh) Parker; (Compositae), Hemi, stemless hymenoxys, (N) (V)
Ipag	Ipomopsis aggregata (Pursh) V. Grant; (Polemoniaceae), Hemi, skyrocket gilia, (N) (V)
Ipco	Ipomopsis congesta (Hook.) V. Grant; (Polemoniaceae), Hemi, ballhead gilia, (N) (V)
KOCHI	Kochia sp.
Koir	Kochia iranica Bornm.; (Chenopodiaceae), Ther, summer cypress (I)
	Kochia scoparia; See Kochia iranica
LACTU	Lactuca sp.
Lase	Lactuca serriola L.; (Compositae), Ther, prickly lettuce, (I)
LAPPU	Lappula sp.
Lare	Lappula redowskii (Hornem.) Greene; (Boraginaceae), Ther, annual stickseed, (N) (V)
LEPID	Lepidium sp.
Lemo	Lepidium montanum Nutt.; (Cruciferae), Hemi, pepperweed, (I) (V)
Lepe	Lepidium perfoliatum L.; (Cruciferae), Ther, clasping pepperweed, (I) (V)
Lepu	Leptodactylon pungens (Torr.) Rydb.; (Polemoniaceae), Hemi, (N) (V)
Lipo	Ligusticum porteri C.& R.; (Umbelliferae), Hemi, Porter ligusticum, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Liki	Linum kingii Wats. in King; (Linaceae), Hemi, flax, (N) (V)
Lile	Linum lewisii Pursh; (Linaceae), Hemi, Lewis flax, (N) (V)
LITHO	Lithospermum sp.
Liin	Lithospermum incisum Lehm.; (Boraginaceae), Hemi, gromwell, (N) (V)
Liru	Lithospermum ruderale Dougl. in Lehm.; (Boraginaceae), Hemi, (N) (V)
LOMAT	Lomatium sp.
Logr	Lomatium grayi C. & R.; (Umbelliferae), Cryp, desert parsley, (N) (V)
Loju	Lomatium juniperinum (M.E. Jones) C. & R.; (Umbelliferae), Cryp, desert parsley, (N) (V)
Loor	Lomatium orientale C.& R.; (Umbelliferae), Cryp, desert parsley, (N) (V)
LUPIN	Lupinus sp.
Luar	Lupinus argenteus Pursh; (Leguminosae), Hemi, silvery lupine, (N) (V)
Luca	Lupinus caudatus Kellogg; (leguminosae), Hemi, tailcup lupine, (N) (V)
Lyju	Lygodesmia juncea (Pursh) D. Don.; (Compositae), Hemi, rush skeletonplant, (N) (V)
MALVA	Malva sp.; (Malvaceae), Hemi, mallow (N)
Mear	Mentha arvense L.; (Labiateae), Hemi, field mint, (N) (V)
MENTZ	Mentzelia sp.
Meal 2	Mentzelia albicaulis Dougl. ex Hook.; (Loasaceae), Ther, whitestem mentzelia, (N) (V).

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Memu 2	Mentzelia multicaulis (Osterhout) Goodman; (Loasaceae), Hemi, mentzelia, (N) (V)
Memu	Mentzelia multiflora (Nutt.) Gray; (Loasaceae), Hemi, desert mentzelia, (N) (V)
MERTE	Mertensia sp.
Meci	Mertensia ciliata (James) G. Don; (Broaginaceae), Hemi, mountain bluebells, (N) (V)
Mopa	Moldavica parviflora (Nutt.) Britton; (Labiateae), Ther, American dragonhead, (N) (V)
MOSS	Moss
Niat	Nicotiana attenuata Torr. ex. S. Wats.; (Solanaceae), Ther, Coyote tobacco, (N) (V)
Oeca	Oenothera caespitosa Nutt.; (Onograceae), Hemi, tufted evening-primrose
Oeco	Oenothera coronopifolia T. & G.; (Onograceae), Hemi, evening-primrose, (N) (V)
Oela	Oenothera lavandulaefolia T. & G.; (Onograceae), Hemi, lavenderleaf evening-primrose, (N) (V)
OSMOR	Osmorhiza sp.
Osde	Osmorhiza depauperata Phil.; (Umbelliferae), Hemi, sweetroot, (N) (V)
Oxla	Oxytropis lambertii var. bigelovii A. Gray; (Leguminosae), Hemi, Lambert crazyweed, (N) (V)
PENST	Penstemon sp.
Peca	Penstemon caespitosus Nutt. ex. A. Gray; (Scrophulariaceae), Hemi, mat penstemon, (N) (V)
Pefr	Penstemon fremontii T. & G.; (Scrophulariaceae), Hemi, beardtongue, (N) (V)
Peos	Penstemon osterhoutii Pennell; (Scrophulariaceae), Hemi, beardtongue, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Pest	Penstemon strictus Benth. in D.C.; (Scrophulariaceae), Hemi, Rocky Mountain penstemon, (N) (V)
Phse	Phacelia sericea (Graham) A. Gray; (Hydrophyllaceae), Hemi, silky phacelia, (N) (V)
PHLOX	Phlox sp.
Phho	Phlox hoodii Rich.; (Polemoniaceae), Hemi, Hoods phlox, (N) (V)
Phlo	Phlox longifolia Nutt.; (Polemoniaceae), Hemi, longleaf phlox, (N) (V)
Phmu	Phlox multiflora A. Nels.; (Polemoniaceae), Hemi, flowery phlox, (N) (V)
hfl	Physaria floribunda Rydb.; (Cruciferae), Hemi, twinpod, (N) (V)
PLANT	Plantago sp.; (Plantaginaceae), Ther, plantain, (N)
Plpa	Plantago patagonica Jacq.; (Plantaginaceae), Ther, Patagonia Indianwheat, (N)
	Plantago purshii See Plantago patagonica
Posa 3	Polygonum sawatchense Small; (Polygonaceae), Ther, knotweed, (N) (V)
POTEN	Potentilla sp.
Pomo	Potentilla monspeliensis L.; (Rosaceae), Ther, cinquefoil, (origin uncertain) (V)
Popu	Potentilla pulcherrima Lehm.; (Rosaceae), Hemi, cinquefoil (N) (V)
Poqu	Potentilla quinquefolia Rydb.; (Rosaceae), Hemi, cinquefoil, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Pyas	Pyrola asarifolia Michx.; (Ericaceae), Hemi, alpine pyrola, (N) (V)
RANUN	Ranunculus sp.
Racy	Ranunculus cymbalaria var. saximontanus Fernald; (Ranunculaceae), Hemi, Rocky Mountain buttercup, (N) (V)
Rasc 2	Ranunculus sceleratus L.; (Ranunculaceae), Hemi, blister buttercup, (N) (V)
RORIP	Rorippa sp.
Rona	Rorippa nasturtium-aquaticum (L.) Schniz & Thell.; (Cruciferae), Hemi, watercress, (I) (V)
Rucr	Rumex crispus L.; (Polygonaceae), Hemi, curlydock, (N) (V)
Ruut	Rumex utahensis Rech, f.; (Polygonaceae) Hemi, dock, (N) (V)
Saka	Salsola kali L.; (Chenopodiaceae), Ther, Russianthistle, (I) (V)
Scla	Scrophularia lanceolata Pursh,(Scrophulariaceae), Hemi lanceleaf figwort, (N) (V)
SENEC	Senecio sp.
Sein	Senecio integerrimus Nutt.; (Compositae), Hemi, lambstongue groundsel, (N) (V)
Semu 2	Senecio multilobatus T.& G. ex A. Gray; (Compositae), Hemi, lobeleaf groundsel, (N) (V)
Sesp	Senecio spartioides T&G(Compositae), Hemi, broom groundsel, (N) (V)
SISYM	Sisymbrium sp.
Sial	Sisymbrium altissimum L.; (Cruciferae), Ther, tumblemustard, (N) (V)
Sili	Sisymbrium linifolium Nutt. in T.& G.; (Cruciferae), Hemi, tumblemustard, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
SMILA	Smilacina sp.
Smra	Smilacina racemosa var. amplexicaulis (Nutt.) S. Wats.; (Liliaceae), Cryp, Solomon-plume, (N) (V)
Smst	Smilacina stellata (L.) Desf.; (Liliaceae), Cryp, Solomon-plume, (N) (V)
SOLID	Solidago sp; (Compositae), Hemi, goldenrod, (N) (V)
	Solidago ciliosa See: Solidago multiradiata var. scopulorum
Somu	Solidago multiradiata Ait. var. scopulorum A. Gray; (Compositae) Hemi, low goldenrod, (N) (V)
SPHAE	Spaheralcea sp.
Spco	Sphaeralcea coccinea (Pursh) Rydb.; (Malvaceae), Hemi, scarlet globemallow, (N) (V)
Stpi 2	Stanleya pinnata (Pursh) Britton; (Cruciferae), Hemi, desert princesplume, (N) (V)
Stwr	Stanleyella wrightii See: Thelypodium wrightii
Stco	Streptanthus cordatus Nutt. ex T.& G.; (Cruciferae), Hemi, heartleaf twistflower, (N) (V)
TARAX	Taraxacum sp.
Taof	Taraxacum officinale Web. in Wiggers; (Compositae), Hemi, common dandelion, (Distribution worldwide) (V)
Thfe	Thalictrum fendleri Engelm. ex A. Gray; (Ranunculaceae), Hemi, Fendler meadowrue, (N) (V)
Thwr	Thelypodium wrightii A. Gray; (Curciferae), Hemi or Ther, (N) (V)

Abbrev.	Species
	HERBACEOUS (NON GRASSLIKE) (Cont.)
Thmo	Thermopsis montana Nutt. ex T.& G.; (Leguminoseae), Hemi, mountain thermopsis, (N) (V)
Toin	Townsendia incana Nutt.; (Compositae), Hemi, hoary townsendia, (N) (V)
TRIFO	Trifolium sp.
Trgy	Trifolium gymnocarpon Nutt.; (Leguminoseae), Hemi, hollyleaf clover, (N) (V)
UMBEL	Umbelliferae
Urdig	Urtica dioica ssp. gracilis (A.T.) Selander; (Labiatae), Hemi or Ther, big stinging nettle, (N)
Vaoc	Valeriana occidentalis Heller; (Valerianaceae). Hemi, western valerian, (N) (V)
Viam	Vicia americana Muehl. ex. Willd.; (Leguminoseae), Hemi American vetch, (N) (V)
	Viguiera multiflora See: Gymnolomia multiflora
Viad	Viola adunca Smith; (Violaceae), Hemi, Hook violet, (N) (V)
Vicar	Viola canadensis L. var. rugulosa (Greene) C.L. Hitchcock; (Violaceae), Hemi, Canada violet (N) (V)
Vinu	Viola nuttallii Pursh; (Violaceae), Hemi, Nuttall violet, (N) (V)
Vipa 2	Viola pallens (Banks) Brainerd; (Violaceae), Hemi, marsh violet, (N) (V)
	Viola palustris ssp. brevipes; See Viola pallens
	Viola rugulosa; See Viola canadensis var. rugulosa

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
WYETH	Wyethia sp. Nutt.; (Compositae), mule-ears
Zyveg	Zygadenus venenosus var. gramineus (Rydb.) Walsh ex M.E. Peck; (Liliaceae), Cryp, grassy deathcamas, (N) (V)
	GRASSES AND GRASS-LIKES
AGROP	Agropyron sp.
	Agropyron cristatum; See Agropyron desertorum
Agde 2	Agropyron desertorum (Risch.) Schult.; (Gramineae), Hemi, crested wheatgrass, (I) (N)
	Agropyron inerme; See Agropyron spicatum var. inerme
Agre 2	Agropyron repens (L.) Beauv.; (Gramineae), Hemi, quackgrass, (I) (V)
Agsm	Agropyron smithii Rydb.; (Gramineae), Bluestem wheatgrass, (N) (V)
Agspi	Agropyron spicatum (Pursh) Scribn. & Smith var. inerme Heller; (Gramineae), Hemi, beardless bluebunch wheatgrass, (N) (V)
Agsp	Agropyron spicatum (Pursh) Scribn. & Smith var. spicatum; (Gramineae), Hemi, bearded bluebunch wheatgrass, (N) (V)
Agsu	Agropyron subsecundum (Link) Hitchc.; (Gramineae), bearded wheatgrass, (N) (V)
Agtr	Agropyron trachycaulum (Link) Richt; (Gramineae), Hemi, slender wheatgrass, (N) (V)
ARIST	Aristida sp. L. Three awn, (N)
Bogr	Bouteloua gracilis (H.B.K.) Lag.; (Gramineae), Hemi, blue grama, (N) (V)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
BROMU	Bromus sp.
	Bromus anomalus; See Bromus porteri
Brin	Bromus inermis Leyss; (Gramineae), Hemi, smooth brome, (I) (V)
Brma	Bromus marginatus Nees; (Gramineae), Hemi, big mountain brome, (N) (V)
Brpo	Bromus porteri, (Coult.) Nash; (Gramineae), Hemi, nodding brome, (N)
Brte	Bromus tectorum L.; (Gramineae), Ther, cheatgrass brome, (I) (V)
CAREX	Carex sp.
Cado	Carex douglasii Boot in Hook.; (Cyperaceae), Cryp, Douglas sedge, (N) (V)
Cage	Carex geyeri Boott; (Cyperaceae), Cryp, elk sedge, (N) (V)
Cala 2	Carex lanuginosa Michx.; (Cyperaceae), Cryp, wooly sedge, (N) (V)
Cane 2	Carex nebraskensis Dewey; (Cyperaceae), Cryp, Nebraska sedge, (N) (V)
Cave 2	Carex vernacula L.H. Bailey; (Cyperaceae), Cryp, sedge, (N) (V)
Dist	Distichlis stricta (Torr.) Rydb.; (Gramineae) Hemi, inland saltgrass, (N) (V)
Elma	Eleocharis macrostachya Britt.; (Cyperaceae), Cryp, common spikerush, (N) (V)
ELYMU	Elmus sp.
Elci	Elymus cinereus Scribn. & Merr.; (Gramineae), Hemi, great basin wildrye, (N) (V)
FESTU	Festuca sp.; (Gramineae), Hemi, fescue, (N)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
Glst	Glyceria striata (Lam.) Hitchcock; (Gramineae), Hemi, fowl mannagrass, (N) (V)
HORDE	Hordeum sp.
Hobr	Hordeum brachyantherum Nevski; (Gramineae), Hemi, meadow barley, (N) (V)
Hoju	Hordeum jubatum L.; (Gramineae), Hemi, foxtail barley, (N) (V)
JUNCU	Juncus sp.
Juara	Juncus articus spp. ater (Rydb.) Hulten; (Juncaceae), Cryp, wiregrass, (N) (V)
	Juncus balticus; See Juncus arcticus spp. ater
Jusa	Juncus saximontanus A. Nels.; (Juncaceae) Cryp, Rocky Mountain rush, (N) (V)
	Koeleria cristata; See Koeleria gracilis
Kogr	Koeleria gracilis Pers.; (Gramineae), Hemi, prairie junegrass
Mebu	Melica bulbosa Geyer; (Gramineae), Cryp, onion grass, (N)
Orhy	Oryzopsis hymenoides (R.& S.) Ricker; (Gramineae), Hemi, Indian ricegrass, (N) (V)
POA	Poa sp.
Poag	Poa agassizensis Boivin & D. Loeve; (Gramineae), Hemi, blue grass, (N) (V)
Poam	Poa ampla Merr.; (Gramineae), Hemi, big bluegrass, (N) (V)
Poca	Poa canbyi (Scribn.) Piper; (Gramineae), Hemi, Canby bluegrass, (N) (V)
Poco	Poa compressa L.; (Gramineae), Hemi, Canada bluegrass, (N) (N)
Pofe	Poa fendleriana (Steud.) Vasey; (Gramineae), Hemi, mutton bluegrass, (N) (V)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
	Poa interior; See Poa nemoralis var. interior
Ponei	Poa nemoralis L. var. interior (Rydb.) Butters & Abbe; (Gramineae), Hemi, interior bluegrass, (N) (V)
Popr	Poa pratensis L.; (Gramineae), Hemi, Kentucky bluegrass, (I) (V)
Posa	Poa sandbergii Vasey; (Gramineae), Hemi, Sandberg bluegrass, (N) (V)
	Poa secunda; See Poa sandbergii
Scac	Scirpus acutus Muehl. ex. Bigelow; (Cyperaceae), Cryp, tule bulrush, (N) (V)
	Sitanion hystrix; See Sitanion longifolium
Silo	Sitanion longifolium J.G. Smith; (Gramineae), Hemi, squirreltail, (N) (V)
Spai	Sporobolus airoides (Torr.) Torr.; (Gramineae), Hemi, alkali sacaton, (N) (V)
STIPA	Stipa sp.
Stco 2	Stipa columbiana Mocoun; (Gramineae), Hemi, subalpine needlegrass. (N) (V)
Stco	Stipa comata Trin. & Rupr.; (Gramineae), Hemi, needle-and-thread, (N) (V)
Stvi	Stipa viridula, Trin.; (Gramineae), Hemi, green needlegrass, (N)
Trma 3	Triglochin maritima L.; (Juncaginaceae), Cryp, shore podgrass, (N)
Tyla	Typha latifolia L.; (Typhaceae), Cryp, common cattail, (N)

FOOTNOTES

1/ Abbreviation of genus and species in a four letter code (Plummer et al., 1966).

2/ Author citation, nomenclatural authority cited after each species name and delineated by a semicolon.

3/ The family of plants to which a species belongs in parenthesis.

4/ Lifeforms of Plants (Raunkiaer, 1934).

Phan (Phanerophyte) - Perennating bud at least 0.25 m above soil surface.

Cham (Chamaephyte) - Perennating bud between 0 and 0.25 m above soil surface.

Hemi (Hemicryptophyte) - Perennating bud in soil surface.

Cryp (Cryptophyte) - Perennating buds covered by soil or water.

Ther (Therophyte) - Annual plants, perennating buds contained in seed.

Succ (Succulent) - Stems enlarged; serve as water storage organ.

5/ (V) Voucher speciment collected.

6/ Origin of herbaceous species:

(N) - Native to the North American Continent.

(I) - Introduced from outside the North American Continent.

ATTACHMENT J-2

SPECIES OF PLANTS OBSERVED IN THE VICINITY OF TRACT C-a DURING 1976

Abbrev. 1/	Species
	TREES
Acne	Acer negundo L.; (Aceraceae), Phan, box elder, (N)(V)
	SHRUBS
Atnu	Atriplex nuttallii S. Wats.; (Chenopodiaceae), Cham, Nuttall saltbush, (N)(V)
Rhtr	Rhus trilobata NuH.; (Anacardiaceae) Phan, skunkbush sumac, (N)(V)
Tape	Tamarix pentandra Pall.; (Tamaricaceae) Phan, Salt cedar, (N)(V)
	HERBACEOUS (NON-GRASSLIKE)
Asca	Aster campestris Nutt.; (Compositae), Cham, aster, (N)(V)
Atar	Atriplex argentea Nutt.; (Chenopodiaceae), Ther, annual saltbush, (N)(V)
Atho	Atriplex hortensis L.; (Chenopodiaceae) Ther, Orache, (I)(V)
Bahy	Bassia hyssopifolia (Pall.) Kuntze; (Chenopodiaceae), Ther, five hook bassia, (I)(V)
Chru	Chenopodium rubrum L.; (Chenopodiaceae), Ther, red goosefoot, (origin uncertain), (V)
Memu	Mentzelia multicaulus Osterhout/Goodman; (Loasaceae), Hemi, mentzelia, (N)(V)
Niat	Nicotiana attenuata Wats.; (Solanaceae), Ther, coyote tobacco, (N)(V)
Orfa	Orobanche fasciculata Nutt.; (Orobanchaceae), Hemi, broomrape, (N)(V)
Plpa	Plantago patagonica Jacq.; (Plantaginaceae), Ther, Patagonia Indianwheat, (N)(V)
Seam	Senecio ambrosioides Rydb.; (Compositae), Ther, groundsel, (N)(V)
Sede	Senecio debilis Nutt.; (compositae), Hemi, groundsel, (N)(V)
Sesp	Senecio spartioides Tit G.; (Compositae), Hemi, broom groundsel, (N)(V)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Continued)
Thwr	Thelypodium wrightii A. Gra; (Cruciferae), Hemi, thelypody, (N)(V)
	HERBACEOUS (GRASS-LIKE)
Agal	Agrostis alba L.; (Graminae), Cham, redtop, (I)(V)
Cado	Carex douglasii Boott in Hook.; (Cyperaceae), Cham, sedge, (N)(V)
Dist	Distichlis stricta (Torr.) Rydb.; (Gramineae), Cham, inland saltgrass, (N)(V)
Muas	Muhlenbergia asperifolia (Nees et Mey) Parodi; (Gramineae), alkali muhly, (N)(V)
Popa	Poa palustris L.; (Gramineae), Hemi, fowl bluegrass, (N)(V)

1/ Abbreviations

Lifeforms

Phan - Perennating bud at least 0.25 m above soil surface.
Cham - Perennating bud between 0 and 0.25 m above soil surface.
Hemi - Perennating bud in soil surface.
Cryp - Perennating buds covered by soil or water.
Ther - Annual plants perennating buds contained in seed.
Succ - Stems enlarged; serve as water storage organ.
(N) - Native
(I) - Introduced
(V) - Voucher specimen collected

EXHIBIT
K

EXHIBIT K

CLIMATE

EXHIBIT K - CLIMATE

The proposed mining area (Tract C-a) is surrounded by high mountains. As a result, many migratory low pressure systems are deflected around the region. Stationary high-pressure cells often persist for several days, their passage blocked by the Continental Divide east of Tract C-a. As a result, there is a high frequency of clear sunny days with light winds and large diurnal temperature changes. Gradient winds are generally westerly, existing throughout the year, except when interrupted by the passage of frontal systems. Annual precipitation is relatively low (Table K-1). There is a high degree of meteorological variability in this area, due to the rough terrain and the variations in elevation and exposure. Thundershowers are isolated and sporadic.

Local topography within the Tract C-a area has pronounced effect on surface wind flows. Specific air movements produced by local conditions often vary from expected gradient westerlies. Gradient wind velocities are lowest at sunrise, when there is little vertical thermal mixing and the lower surface air does not couple with the more freely moving upper air. Conversely, velocities of local winds are greatest in the early afternoon hours when the air exhibits its greatest tendency to move vertically due to terrestrial heating, and couples with the faster air moving above it.

In the absence of strong gradient winds, the local terrain produces special meteorological conditions. During warm afternoon hours, the laterally constricted, but vertically expanding, air tends to flow up the valley. This air motion probably develops simultaneously with anabatic (upslope) winds which result from a greater heating of the valley side than the valley floor. At night, the reverse process occurs with the cold, dense air at higher elevations draining into the depressions. The greater radiative heat loss affecting the higher elevations (especially if they are snow covered) cools the air immediately adjacent to the surface, and this air sinks into the valley. Downward flowing cold air set in motion by this effect forms downslope winds leading to an accumulation of cold, dense,

TABLE K-1

PRECIPITATION (INCHES) RECORDED AT FOUR LOCATIONS NEAR TRACT C-a, 1975 and 1976

1975 - Seasonal	Site 1	Site 2	Site 3	Site 4	Average
Winter (February)	0.01	0.04	0.05	0.32	0.11
Spring (March, April, May)	0.39	0.20	1.11	2.58	1.07
Summer (June, July, August)	0.11	0.06	0.33	1.04	0.39
Fall (September, October, November)	0.12	0.43	0.93	1.76	0.81
Winter (December, January)	0.02	0.01	0.47	0.27	0.19
Annual (February 1975 through January 1976)	0.65	0.74	2.89	5.97	2.56
1976 - Seasonal					
Winter (February)	0.57	0.02	0.46	0.67	0.43
Spring (March, April, May)	1.87	1.92	2.33	2.76	2.22
Summer (June, July, August)	2.79	3.54	3.52	3.61	3.12
Fall (September, October November)	0.51[2/]	0.03[2/]	0.99	0.83	0.91
Winter (December, January)	0.06	0.46	0.45	0.11	0.27
Annual (February 1976 through January 1977)	5.80[2/]	5.97[2/]	6.75	7.98	7.37[3/]

[1/] Average is based upon sites with complete data only.

[2/] Partial data only

[3/] Average of annual site averages using site with complete data only.

NA - Data not available.

stable air in the valley bottom. The high Cathedral Bluffs to the west of Tract C-a and the deep gulches to the east effectively channel surface winds, and thereby decouple the upper level flows from the surface flows much of the time.

The climatology of Tract C-a and the surrounding (50-mile radius) area is summarized in Table K-2 which shows the ambient temperature, annual precipitation, and evaporation rate at 15 adjacent weather stations, plus three operated by the Rio Blanco Oil Shale Project.

Long-range regional data indicate that annual precipitation averages 10 to 12 inches per year, with moderate ambient temperatures during the spring, summer, fall, and low wintertime minima.

Seasonal site specific temperature data taken at Met Station number 4 show wintertime minima ranging around -30 C, (22F) with summertime maxima of around +30 C, (86F) (Table K-3).

Annual summaries of site specific climatological data are presented in Table K-4. Included are: wind speed and direction, annual temperature averages, and relative humidity. Data are for the years 1975 and 1976.

TABLE K-2

COMPARISON OF TEMPERATURE, PRECIPITATION, AND EVAPORATION DATA IN THE TRACT C-a VICINITY (50-MILE RADIUS) FOR 1975, RBOSP

Station	County	Air Temperatures (F) Min	Max	Mean	Dep[1]	Precip (in.) Amt	Dep[1]	Evap (in.) Amt	Dep[1]
Altenbern	Garfield	-17	95	44	--	14.66	--		
Colbran, 2 Miles southwest	Mesa	-18	94	--	--	13.05	--		
Colorado Natl Mon	Mesa	-2	95	--	--	11.55	+0.56		
Dinosaur Natl Mon	Moffat	-11	96	46	--	13.69	--		
Fruita	Mesa	-18	98	49	-1.8	9.43	+1.13		
Grand Junction Arpt	Mesa	-8	99	50	-2.5	9.18	+0.77	38.36[2]	-5.2[3]
Grank Junction, 6 miles east-southeast	Mesa	-6	98	--		9.45	--		
Grand Valley	Garfield	-13	101	47	--	10.51	--		
Little Hills	Rio Blanco	-29	93	--	--	15.34	--		
Meeker No. 2	Rio Blanco	-22	91	43	--	12.72	--		
Palisade	Mesa	-2	100	51	-3.6	9.11	0.00		
Rangely	Rio Blanco	-18	98	44	--	11.13	--		
Rifle	Garfield	-20	95	44	-2.9	9.24	-2.00		
Site 4 Met Station(RBOSP)	Rio Blanco	-28	92	41[5]	--	5.97[6]	--	27.56[4]	--
Cathedral Bluffs(RBOSP)	Rio Blanco	--	--	--	--	16.30[8]	--	--	--
Tract Stations (RBOSP)	Rio Blanco	--	--	--	--	13.25[9]	--	--	--

[1] Departure from normal
[2] Total amount of evaporation for four months: May, June, July, and September 1975.
[3] Average monthly departure from normal, four-month period
[4] Total evaporation, in inches, as measured at Site 3, RBOSP, for 4-1/2 months, 1 June through 18 October 1975.
[5] Average of all four sites
[6] Total for the year for the study site having the highest total amount
[7] Temperatures at 10-m level.
[8] Period of record - November 1974 thru September 1975
[9] Period or record - December 1977 thru September 1974

EXHIBIT O - SOURCE OF LEGAL RIGHT TO ENTER

Attachment A-1 is a copy of the Federal Tract C-a Oil Shale Lease and Environmental Stipulations which grants Standard Oil Company (Indiana) and Gulf Oil Corporation a legal right to enter and mine.

EXHIBIT P

OWNERS OF RECORD OF AFFECTED LAND & OWNERS OF SUBSTANCE TO BE MINED

EXHIBIT
P

EXHIBIT P - OWNERS OF RECORD OF AFFECTED LAND AND OWNERS OF SUBSTANCE TO BE MINED

The owners of the surface of Tract C-a are shown in Figure C-1.* As stated in the lease, Attachment A-1, the Federal Government owns the oil shale, the "substance to be mined," on Tract C-a.

* Volume II

TABLE K-4

SUMMARY OF ANNUAL CLIMATOLOGICAL PARAMETERS FOR TRACT C-a
RIO BLANCO COUNTY, COLORADO

Parameter	Units	1975 Minimum[1/]	1975 Maximum[1/]	1975 Mean	1976 Minimum[1/]	1976 Maximum[1/]	1976 Mean
				Site 1			
Wind Speed (10 m)	mph	0.56	30.82	7.72	0.61	32.31	7.18
Wind Speed (30 m)	mph	0.56	39.12	9.04	0.60	36.25	8.66
Wind Speed (60 m)	mph	0.53	43.04	10.59	0.56	56.61	10.04
Wind Direction σ (10 m)	Degrees	0.01	59.26	11.77	0.39	34.52	11.88
Air Temperature (10 m)	C	-21.10	30.07	6.08	-21.70	29.73	7.22
Air Temperature (30 m)	C	-22.10	27.00	5.56	-21.30	29.06	7.14
Δ Temperature (10 - 60 m)	C	-4.69	6.22	0.11	-4.79	7.43	0.08
Relativity Humidity (10 m)	%	10.00	93.12	35.99	12.13	92.43	30.60
				Site 2			
Wind Speed (10 m)	mph	0.01	36.70	9.08	0.59	39.20	8.40
Temperature (10 m)	C	-21.44	27.47	5.52	-22.20	29.40	6.91
				Site 3			
Wind Speed (10 m)	mph	0.06	29.90	6.61	0.51	26.42	6.92
Air Temperature (10 m)	C	-28.20	28.97	4.33	-25.30	32.11	5.74
				Site 4			
Wind Speed (10 m)	mph	0.00	31.23	5.92	0.54	28.39	5.71
Air Temperature (10 m)	C	-33.30	33.14	4.39	-31.50	33.36	5.01

1/ Hourly values for this period.

TABLE K-4

SUMMARY OF ANNUAL CLIMATOLOGICAL PARAMETERS FOR TRACT C-a
RIO BLANCO COUNTY, COLORADO

Parameter	Units	1975 Minimum[1]	1975 Maximum[1]	1975 Mean	1976 Minimum[1]	1976 Maximum[1]	1976 Mean
				Site 1			
Wind Speed (10 m)	mph	0.56	30.82	7.72	0.61	32.31	7.18
Wind Speed (30 m)	mph	0.56	39.12	9.04	0.60	36.25	8.66
Wind Speed (60 m)	mph	0.53	43.04	10.59	0.56	56.61	10.04
Wind Direction σ (10 m)	Degrees	0.01	59.26	11.77	0.39	34.52	11.88
Air Temperature (10 m)	C	-21.10	30.07	6.08	-21.70	29.73	7.22
Air Temperature (30 m)	C	-22.10	27.00	5.56	-21.30	29.06	7.14
Δ Temperature (10 - 60 m)	C	-4.69	6.22	0.11	-4.79	7.43	0.08
Relativity Humidity (10 m)	%	10.00	93.12	35.99	12.13	92.43	30.60
				Site 2			
Wind Speed (10 m)	mph	0.01	36.70	9.08	0.59	39.20	8.40
Temperature (10 m)	C	-21.44	27.47	5.52	-22.20	29.40	6.91
				Site 3			
Wind Speed (10 m)	mph	0.06	29.90	6.61	0.51	26.42	6.92
Air Temperature (10 m)	C	-28.20	28.97	4.33	-25.30	32.11	5.74
				Site 4			
Wind Speed (10 m)	mph	0.00	31.23	5.92	0.54	28.39	5.71
Air Temperature (10 m)	C	-33.30	33.14	4.39	-31.50	33.36	5.01

1/ Hourly values for this period.

CONFIDENTIAL

NOT TO BE RELEASED WITHOUT WRITTEN PERMISSION FROM GULF AND STANDARD

EXHIBIT L

EXHIBIT L

RECLAMATION COSTS

EXHIBIT L - RECLAMATION COSTS

The following is the anticipated reclamation costs (in 1977 dollars) for each phase of the reclamation program.

a)	Segregation of Surface Soils	$215,000 - 275,000
b)	Temporary Erosion Control Seed: $19/acre x 5 acres = 95 Seeding: $100/acre x 5 acres = $500	595
c)	Topsoiling	$245,000 - 310,000
d)	Seedbed Preparation $25/acre x 151 acres = 3775	3,775
e)	Seeding Seed: Corridors $52.66/acre x 51 acres = 2685 Mine Area $76.66/acre x 100 acre = 7700 Labor: $100/acre x 151 acres = 15,100	25,485
f)	Mulching $275/acre x 100 acres (disposal area only).	27,500
g)	Fertilizer $100/acre x 151 acres	15,100
h)	Shrub Planting Seedlings: $.75/ind x 300-700 ind/acre x 100 acres = 22,500 - 52,500 Labor: 2000 - 4700 hrs x $5/hr = $10,000 - 23,500	$ 32,500 - 76,000
i)	Management* Irrigation: $400/acre x 100 acres =$40,000 Weed control: $150/acre x 100 acres =$15,000	55,000

* Conditional based on existing conditions.

CONFIDENTIAL
NOT TO BE RELEASED WITHOUT WRITTEN PERMISSION FROM GULF AND STANDARD

EXHIBIT
M

EXHIBIT M

LOCAL GOVERNMENT APPROVAL

EXHIBIT M - LOCAL GOVERNMENT APPROVAL

The Board of County Commissioners of Rio Blanco County, by Resolution dated June 6, 1977, "passed, adopted and approved" a Conditional Use Request for the RBOSP Tract C-a. (See Figure M-1, page M-2).

RESOLUTION

WHEREAS, STANDARD OIL & GULF OIL has submitted a request for a conditional use as set forth in the request attached hereto and incorporated herein by reference, and

WHEREAS, the Planning Commission of Rio Blanco County has recommended that said conditional use be granted, and

WHEREAS, the Board of County Commissioners of Rio Blanco County has conducted a public hearing pursuant to notice, in accordance with the requirements of the Rio Blanco County Zoning Ordinance.

NOW THEREFORE, BE IT RESOLVED by the Board of County Commissioners of Rio Blanco County that the conditional use request attached hereto and incorporated herein by reference be and the same is hereby granted subject to the following conditions: None

PASSED, ADOPTED AND APPROVED this 6th day of June, 1977.

THE BOARD OF COUNTY COMMISSIONERS
OF RIO BLANCO COUNTY

Chairman

ATTEST:

Sue W. Mantle, County Clerk

Figure M-1

EXHIBIT
N

EXHIBIT N

OTHER PERMITS OR LICENSES

EXHIBIT N - OTHER PERMITS OR LICENSES

The following list is included to answer Section 2.12(14) of the Board's Rules and Regulations concerning other permits and licenses. The permits listed are in various stages of procurement.

REGULATORY REQUIREMENTS

I. FEDERAL

A. Department of Labor

1. Certificate of Non-Segregated Facilities

B. Department of Treasury

1. Explosive Users Permit
2. (Explosive) Manufacturer Limited License

C. Environmental Protection Agnecy

1. Spill Prevention Control and Countermeasure Plan
   a. Preparation
   b. Implementation
2. Application to Construct (PSD)
3. National Pollutant Discharge Elimination System @

D. Department of Army, Corps of Engineers

1. 404 Permit (Dredge and Fill)

E. Department of Transportation, Federal Aviation Administration

1. Private Pilots License
   a. Training Period
   b. Examination Grading
2. Notice of Location and Heliport
3. Air Space Obstruction Determination

F. Federal Communications Commission

1. Microwave Station Authorization
2. Radio Station Authorization
   a. FAA Review and Report
   b. ICC Approval

G. Mining Enforcement and Safety Administration

1. Operator's Notice of Activity (a copy of the State's Notice of Activity should be sent to MESA)
2. MESA Information File (not a permit)
3. Variance Federal Mining Law

H. Bureau Land Management

1. Pipeline Right-of-Way
2. Powerline Right-of-Way
3. Temporary Use Application and Permit

II. STATE

A. Department of Health

CAPCD

1. Air Contaminant Emission Notice
2. Air Contaminant Emission Permit
3. Fugitive Dust Emission Permit
4. Open Burning Permit
5. Incinerator Permit

WQCD

1. Subsurface Disposal System Permit
2. Permit to Discharge Pollutants

3. Review: Site & Facilities for Solid Waste Disposal
4. Site Approval: New Sewage Treatment Works
5. Guidelines (not Regulation) Pertaining to Water Pollution Control
6. Application for Approval of Sewage Collection Facilities

Engineering and Sanitation (EAS)

1. Review: Public and Potable Water Supply Systems

Plant Operators Certification Board (POCB)

1. Certification of Water and Waste Water Treatment Plant Operators

Medical Care Division (MCD)

1. Certificate of Public Necessity re: Health Facilities

Health Facility Division (HFD)

1. License to Operate a Health Facility

Radiation Hygiene Section (RHS)

1. Radioactive Materials License

Consumer Protection Section (CPS)

1. License to Operate a Food Service Establishment

B. Department of Labor & Employment

Division of Labor (DOL)

1. Boiler Inspection Certificate

2. Notice of Intention to Excavate or Trench

3. Explosive Permit

C. Department of Natural Resources

WRD

1. Certificate of Reservoir Dams (State Engineer)

2. Permit to (a) Use Groundwater; (b) Construct Well, (c) Install Pump

Bureau of Mines (BOM)

1. Permit to Transport, Store and Use Explosives

2. Operators Notice of Activity

3. Diesel Engine Operation for Underground Mines

4a. Summary of Permission or Approval (not a permit)

4b. Summary of Reports and Notification (not a permit)

Wildlife Division (WD)

1. Land Use Permit

Mined Land Reclamation Board (MLRB)

1. Regular Reclamation Permit

D. Department of Regulatory AGencies

Electrical Board (ED)

1. Electrical Permit

Public Utilities Commission (PUC)

1. Commercial Carrier Permit

E. Department of Revenue

1. Gross Ton Mile Tax Permit
2. Special Fuel Users Permit

F. Department of Highways

1. Special Transport Permit
2. Mobile Structure Permit (Mobile Homes)

Maintenance Division - Craig

1. Underground and Utility Permit

III. LOCAL

A. Rio Blanco County

1. Amendment to Zoning Map (Rezoning A to H-1)
2. Conditional Use Approval
3. Individual Sewage Disposal System Permit
4. Building Permit
5. Mobile Home Park Operations Ordinance
6. Special Vehicle Permit
7. Solid Waste Disposal Review

The following permits have already been obtained by RBOSP:

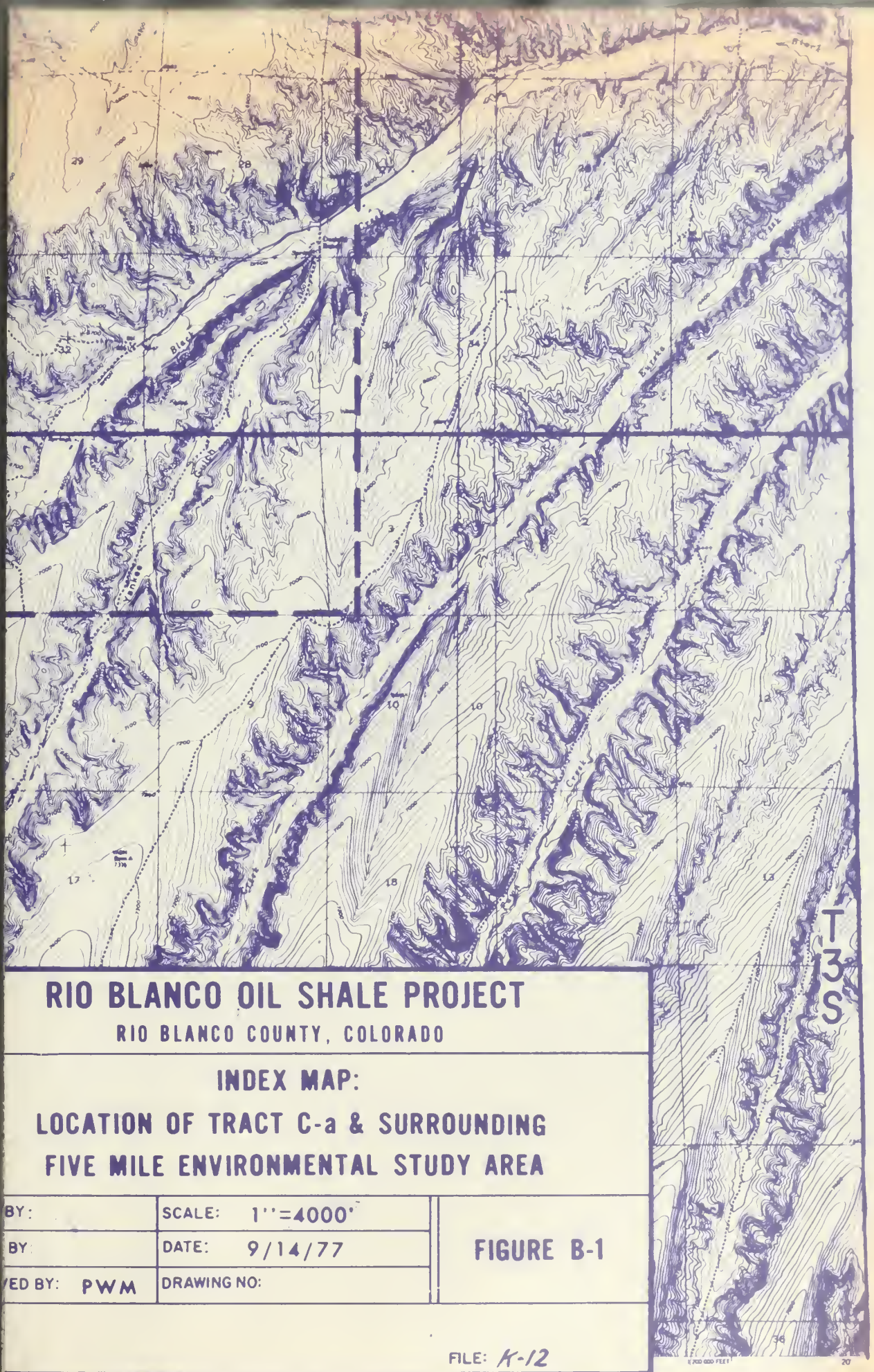
Colorado Dept. of Health
- Fugitive Dust
- NPDES Permit

Rio Blanco County
- Special Use Permit

EXHIBIT
0

EXHIBIT 0

SOURCE OF LEGAL RIGHT TO ENTER



RIO BLANCO OIL SHALE PROJECT

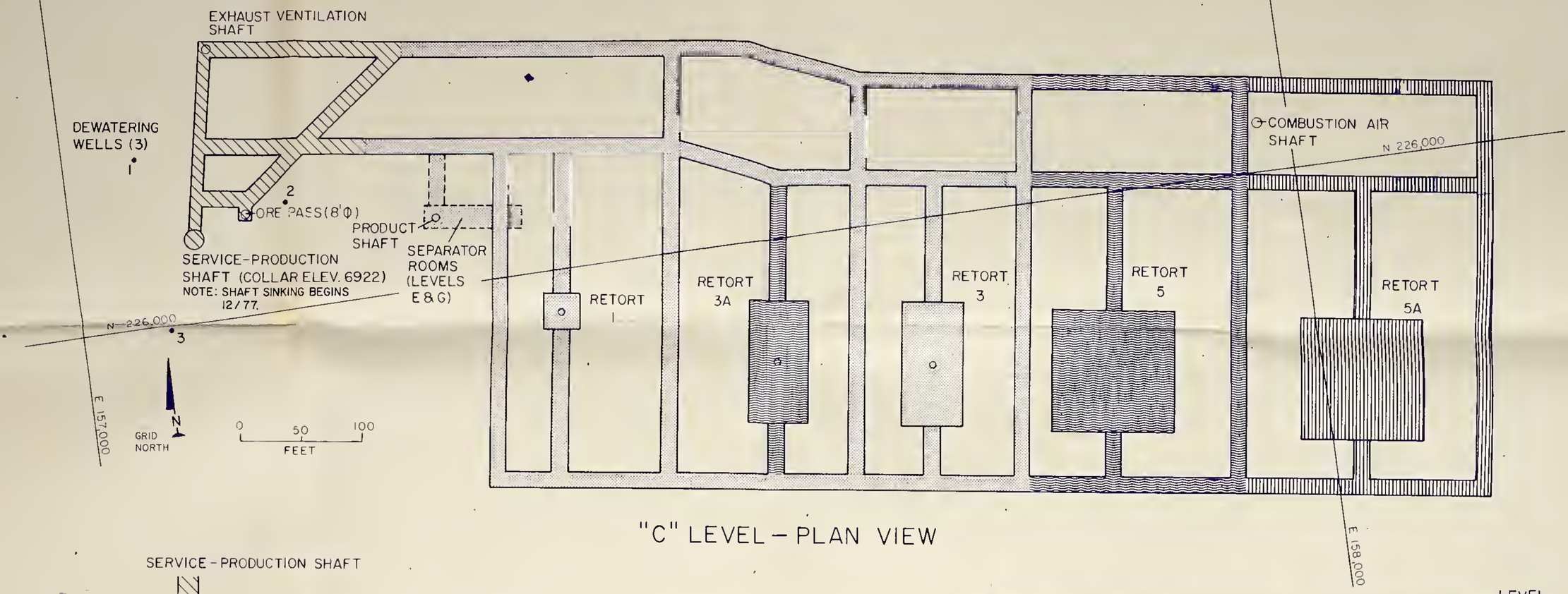
RIO BLANCO COUNTY, COLORADO

INDEX MAP:

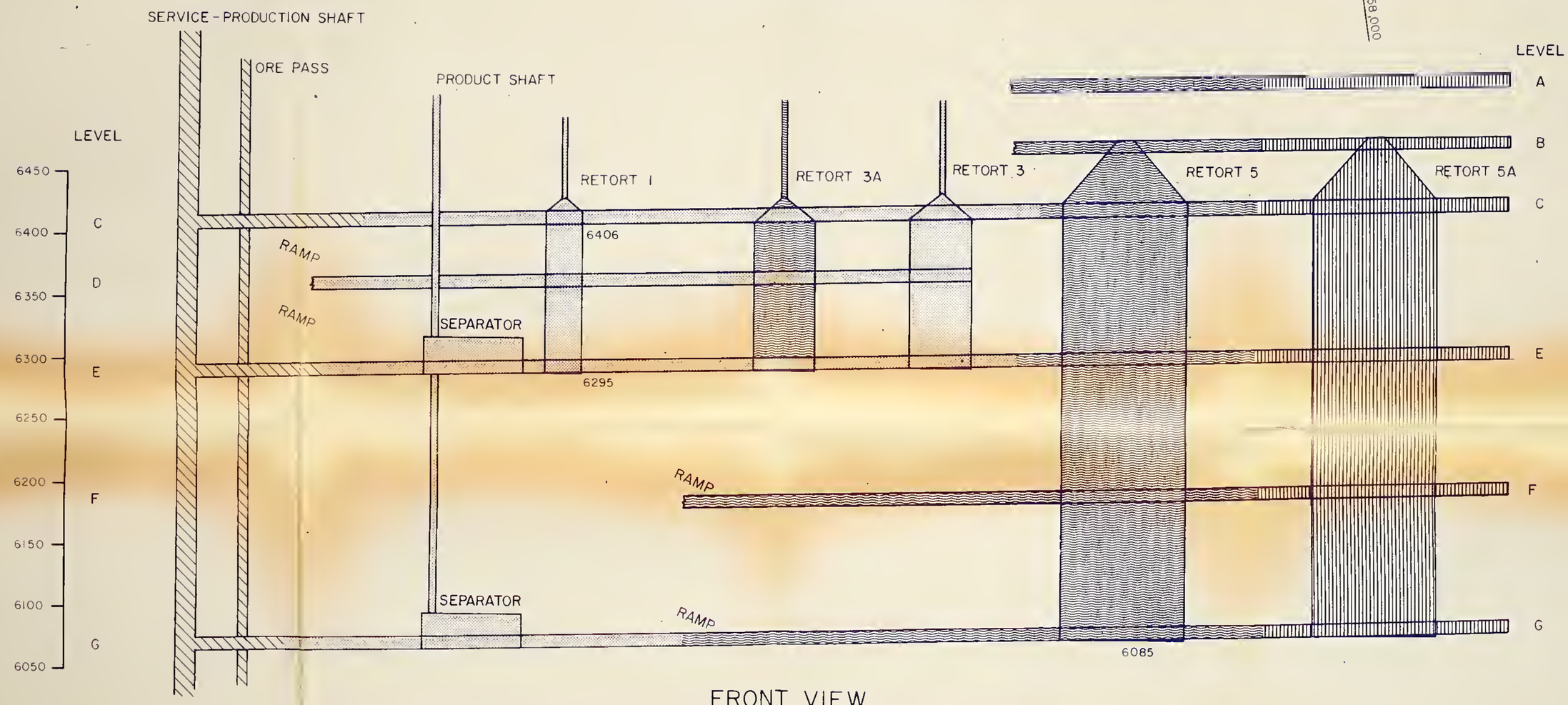
LOCATION OF TRACT C-a & SURROUNDING FIVE MILE ENVIRONMENTAL STUDY AREA

BY:	SCALE: 1"=4000'	FIGURE B-1
BY:	DATE: 9/14/77	
VED BY: PWM	DRAWING NO:	

FILE: K-12



"C" LEVEL – PLAN VIEW



FRONT VIEW

RETORT PROGRESS 1977 TO 1981

1977 – SHAFT SINKING BEGINS 12/77

1978

1979

1980

1981

COORDINATES (APPROXIMATE)

	NORTH	EAST
EXHAUST VENT. SHAFT	226,220	157,130
SERVICE-PROD. SHAFT	226,070	157,100
COMBUSTION AIR SHAFTS		
RETORT 1	225,965	157,390
RETORT 3	225,880	157,685
RETORT 3A	225,900	157,560
RETORTS 5 & 5A	226,040	157,975
RETORT CENTERS		
RETORT 5	225,855	157,830
RETORT 5A	225,820	158,030
PRODUCT SHAFT	226,055	157,300

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY COLORADO

MDP MINE LAYOUT SKETCH

PRELIMINARY

DRAWN BY TKM	SCALE	FIGURE
DESIGN BY	DATE 9-9-77	MF-122
APPROVED BY PWM	DRAWING NO	

FILE

MORRISON - KNUDSEN COMPANY, INC.

REVISIONS

ISSUE "A" FOR RECLAMATION PERMIT
DATE: 8-24-77

ISSUE "B" FOR CMLRB. PERMIT QUESTIONS
DATE: 1/16/78

ISSUE Z 2 CMLRB. UPDATE
DATE: 5/23/78

MORRISON - KNUDSEN COMPANY, INC.

SCALE: 1"=500'

LEGEND
- MONUMENT
- MAIN ROAD
- JEEP TRAIL (4 WHEEL)
- WITHDRAWN SERVICE ROAD
- INJECTION WELL
- WATER WELL (DEEP)
- MONITOR WELL
- 1000 (CONTOUR INTERVAL)
- 1978 - RANGELAND / WILDLIFE HABITAT
- 1982-1983 INDUSTRIAL (SEE TEXT)

RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO

TRACT C-a
AREAS RECLAIMED BY YEAR

SITE PLAN

MORRISON - KNUDSEN COMPANY, INC.

FIGURE F-I

TWO MORRISON-KNUDSEN PLAZA/P.O. BOX 7809/BOISE, IDAHO 83729

DRAWN BY	APPROVED BY	CONTRACT NUMBER
[illegible] 2-25-77		1104
CHECKED BY	SCALE	SHEET NUMBER
	1" = 500'	22-521-030

DEPT.	ARCH.	STRUCT.	MECH.	ELECT.	P & I	PIPING	CAD/DES.	P. E.
INIT.								
DATE								

R99W

T1S

Sec. 29 Sec. 28
Sec. 32 Sec. 33
Sec. 27 Sec. 26
Sec. 34 Sec. 35
Sec. 5 Sec. 4
Sec. 3 Sec. 2

7400 7300 7200 7100 7000 6900 6800 6700

I-8 I-9A I-10A I-12 I-13A I-17 I-124

CE 701 CE 702 CE 703 CE 704 CE 705 CE 706 CE 707 CE 708 CE 709

G-S 2-3 G-S 4 G-S 5 G-S 6 G-S 9

NR-5

DRY

SOIL STORAGE "E"
SOIL STORAGE "C"
SOIL STORAGE "D"
SOIL STORAGE "B"
SOIL STORAGE "A"
SOIL STORAGE "F"

RES #2
RES #3
RES #4
RES #5
RESERVOIR #1

138 KV POWER TRANSMISSION LINE

MINE SERVICES PRECIPITATION POINT
SHAFTS
WEST SETTLING BASIN
EAST SETTLING BASIN
HUNTING CLUB
RUN-OFF CONTAINMENT DITCH
SLOPE 3:1 OR 4:1
TOP DISPOSAL PILE (TOP SOIL) ONE OF 5 AC'S
SOIL STORAGE PILE
EQUIPMENT YARD
EVAPORATION FIELD
RUN-OFF DIVERSION DITCH
PARKING AREA
CHANGE HOUSE
ELECTRIC SUBSTATION
WATER TANK
PIPELINE
WATER PIPELINE
POWDER MAGAZINE
EXPLOSIVES MAGAZINE
PUMP HOUSE
VISITORS CENTER & SAFETY TRAILER

Carter Oil Co.
State Division of Wildlife

MORRISON - KNUDSEN COMPANY, INC.

KLONDIKE NM-1

SOIL STORAGE

CE-708
I-5

G-S7
VM-1

G-S8

G-S9

PARKING AREA
CHAPEL

ELECTRICAL SUBSTATION

WATER TANK

PIPELINE

CE-705-A
I-13

NR-1
I-15

I-14

AM-3

G-S13

G-S12

G-S11

AM-2A

I-16
NR-4

I-17

I-18

NR-5

G-S10

I-19

I-20

AM-4

G-S14

I-21

I-22

I-23

G-S15

T
2
S

Sec. 8

Sec. 9

Sec. 10

Sec. 11

Sec. 17

Sec. 16

Sec.

Sec. 14

RIVER

DITCH

GULCH

MUNSON

NORTH

020-1-25-22

MORRISON - KNUDSEN COMPANY, INC.

R100W R99W R98W

T 1 S

T 2 S

T 3 S

0 1 2 3

MILES

LOCATION AND EXTENT OF VEGETATION TYPES ON TRACT C-a AND VICINITY

TERRESTRIAL ECOLOGICAL INVESTIGATIONS

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

VEGETATION TYPES

KEY

1	2
3	4

1 DOUGLAS FIR	6 PINYON - JUNIPER SAGEBRUSH	11 SHADSCALE
2 ASPEN	7 UPLAND SAGEBRUSH	12 RIPARIAN
3 MIXED BRUSH	8 BOTTOMLAND SAGEBRUSH	13 BALD
4 PINYON - JUNIPER	9 RABBITBRUSH	14 AGRICULTURE
5 PINYON - JUNIPER MIXED BRUSH	10 GREASEWOOD	

R102W

R101W

R100W

R99W

R98W

HWY. 64

HWY. 64

RANGELY

T 1N

T 1S

ROAD

PASS

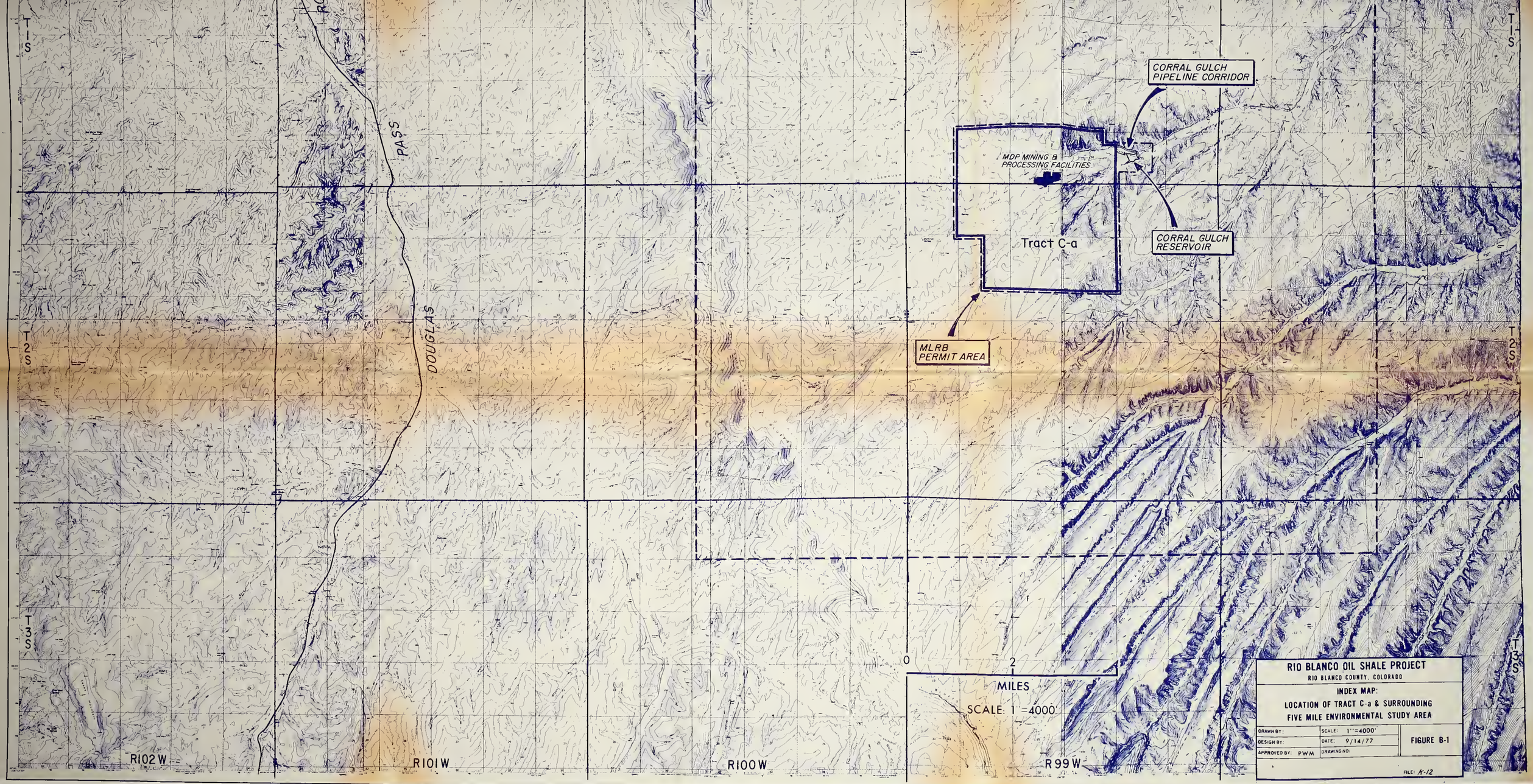
5 MILE PERIMETER ENVIRONMENTAL STUDY AREA

CORRAL GULCH PIPELINE CORRIDOR

MDP MINING & PROCESSING FACILITIES

Tract C-a

CORRAL GULCH RESERVOIR



RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO

INDEX MAP:
LOCATION OF TRACT C-a & SURROUNDING FIVE MILE ENVIRONMENTAL STUDY AREA

DRAWN BY:	SCALE: 1"=4000'	FIGURE B-1
DESIGN BY:	DATE: 9/14/77	
APPROVED BY: PWM	DRAWING NO:	

FILE: A-12

R99W

JEEP

7425 x

7400

7360

7200

7000

6900

6842 x

6800

CORRAL GULCH RESERVOIR

Carter Oil Co.

32

33

34

Hunting Club

RBOSP

MDP MINING & PROCESSING FACILITIES

TRACT C-a

Corral

Spring

Gulch

Elder

7319 x

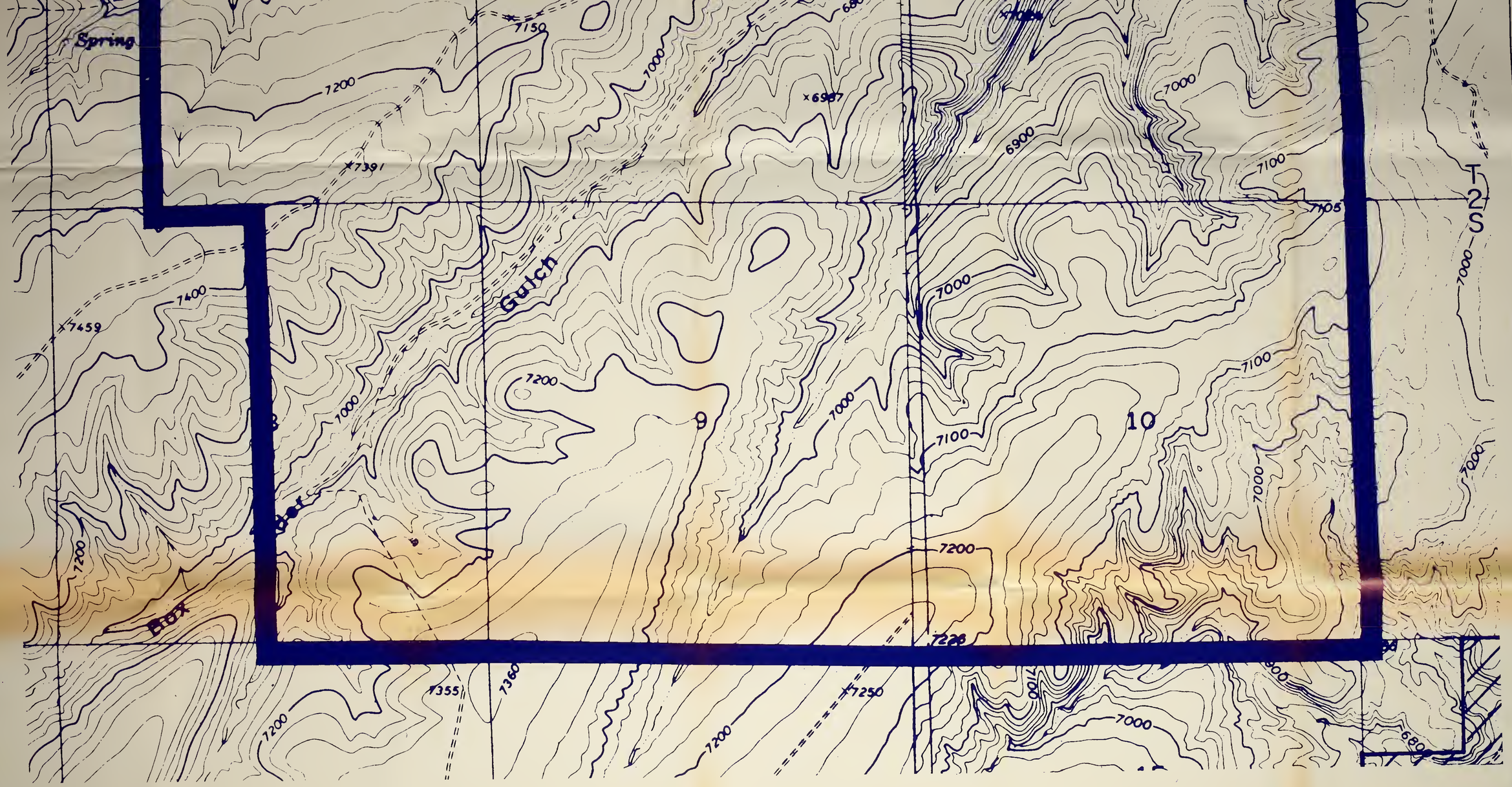
6987 x

6888 x

7150

5

3



0 2500
FEET
1"=500'

LEGEND

PRIVATE LANDS

STATE FISH & WILDLIFE LANDS

BUREAU OF LAND MANAGEMENT LANDS

RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO

SURFACE OWNERSHIP

DRAWN BY:	SCALE: 1"=500'	FIGURE C-1
DESIGN BY:	DATE: 9/14/77	
APPROVED BY: PWM	DRAWING NO:	

FILE: K-12

E 150,000

E 156,000

E 162,000

N 229,000

N 223,000

G-S M-1

CE 701
TO 2

DRY FORK

G-S 2-3

G-S 1

CE 707

CORRAL GULCH

CE 709

MDP MINING & PROCESSING FACILITIES

EXHAUST VENTILATION SHAFT

SERVICE - PRODUCTION SHAFT

COMBUSTION AIR-SHAFT

RETORT 1
RETORT 3A
RETORT 3
RETORT 5
RETORT 5A

EVAPORATION FIELD

STORAGE FACILITIES

FIRST AID TRAILER

TO CE 3
TO 702

VISITORS CENTER

G-S 4-5

STORAGE FACILITIES

G-S 6

CE 708

G-S 9

TO CE 708A

CE 703

G-S 7

G-S 8

ELDER GULCH

G-S 10

MUNSON

BOX ELDER GULCH

MUNSON

G·S O8 G·S O10 G·S O13 G·S O14 G·S O12 G·S O11 G·S O15

AM O3 AM O4 AM O2A

N 218,000 N 213,000

E 146,000 E 150,000 E 156,000 E 162,000 E 168,000

SHEET LAYOUT

1	2	3
4	5	6
7	8	9

GRID NORTH 1°57' TRUE NORTH

ALL INFORMATION CONTAINED ON THIS MAP IS OF A PROPRIETARY NATURE AND SHOULD NOT BE REPRODUCED WITHOUT WRITTEN AUTHORIZATION FROM THE RIO BLANCO OIL SHALE PROJECT.

500 0 500 1000 1500 2000

Scale: 1" = 500'

CONTOUR INTERVAL 5 ft.

LEGEND

- HORIZONTAL & VERTICAL CONTROL
- VERTICAL CONTROL
- HORIZONTAL CONTROL
- DRILL HOLE
- PROPERTY CORNER
- PICTURE CENTER
- SECTION CORNER
- R/S CORNER
- SPOT ELEVATION
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- CONTOUR THRU HEAVY VEGETATION
- DEPRESSION
- PERENNIAL STREAM
- INTERMITTENT STREAM
- DITCH
- POND
- WASH
- CULTIVATION
- GRADED ROAD
- DIRT ROAD
- JEEP TRAIL
- TRAIL
- CULVERT
- FENCE
- FENCE (POSSIBLE)
- GATE
- CORRAL
- PIPE LINE
- BUILDING
- FOUNDATION
- EARTH DAM
- UTILITY POLE
- TREES
- SCATTERED TREES

REVISIONS

NO.	DESCRIPTION	DATE	BY
	Updated Photomosaic Data Obtained Photography Obtained 9-3-74 Added Dim Holes and Control	MAY 1975	L.E.E.

RIO BLANCO OIL SHALE PROJECT
MAP OF TRACT C-a AND VICINITY

MDP MINING, PROCESSING FACILITIES & SURFACE WATER SOURCES

FIGURE C-2

TOPOGRAPHIC MAPPING OF TRACT C-a FEDERAL OIL SHALE LEASE NO. C-20046 AND PORTIONS OF TOWNSHIPS 1&2 SOUTH, RANGES 98, 99&100 WEST RIO BLANCO COUNTY, COLORADO

NOTE: COMPILED BY PHOTOGRAMMETRIC METHODS FROM 1:12,000 PHOTOGRAPHY OBTAINED JUNE 1974 WITH AN RC 8 CAMERA OF 152.74mm FOCAL LENGTH. HORIZONTAL CONTROL SURVEYS REFERRED TO THE COLORADO STATE PLANE COORDINATE SYSTEM, NORTH ZONE MODIFIED TO A 7200 FT. DATUM. LAMBERT CONFORMAL CONIC PROJECTION. VERTICAL CONTROL SURVEYS RELATED TO MEAN SEA LEVEL.

SHEET 5 OF 10

FILE K-12

E 156,000

E 162,000

N

N 228,000

N 223,000

CE-701

TO-2

Leaves Road

Water Reinjection System

G-S 2-3

Soil Storage "E"

DRY FORK GULCH

Leaves Road

Leaves Road

G-S 4-5

Leaves Road

First Aid Station

TO-3

Visitors Center

Access Road Clay Pit

Leaves Road

Impervious Borrow Area

Soil Storage Area

Soil Storage "B"

Soil Storage Area

Soil Storage "C"

C-a Trailer Camp

Leaves Road

Res #1

East Settling Basin

Hunt Club Road

Access Road

Drainage Ditch

Drainage Ditch

Fence

Hunting Club

Berm

Soil Storage Piles

D-7

Res #2

West Settling Basin

GULCH

Mine Area Plant Site & Ponds

ROM Disposal Area

Not Gas Metering Stn

Access

Powder Magazines

Core Storage Building

G-S 6

Soil Storage Pile

S-P Shaft

Evaporation Field

Water Reinjection System

Gas Pipeline 1979

Drainage Ditch

Sub-Sid Monument Access

Re-Location Airplane Ridge Road

Fence

Sanitary Landfill

Water Tank

D-8

CE-707

CE-708

G-S 9

TO-1

D-9

NM-1

G-S 9

NR-5

G-S 8

NR-1

G-S 10

136 KV Power Transmission Line

GULCH

GULCH

GULCH

Legend

- 1977 Disturbance
- 1978 Disturbance
- 1979 Disturbance
- 1980 Disturbooce
- 1978 Seeding
- 1979 Seeding
- No New Disturbonce
- CMLRB Boundry

NOTE:

1. Where feasible corridors were shortened to reduce disturbance
2. See Table I for exact acreages, Disturbance Areas on map ore not to scale

DATE	REVISIONS
3/5/79	P.V.M-Rev.10
6/21/79	C-a Trailer Camp Addition
3/3/80	1979 Disturbance

Rio Blanco Oil Shale Company
RIO BLANCO COUNTY, COLORADO

TRACT C-a
AREAS DISTURBED BY YEAR

DRAWN BY: SS	SCALE: 1"= 500'	FIGURE: E-162
CONT. NO.	DATE: 6/20/79	
APPROVED BY	DRAWING NO:	

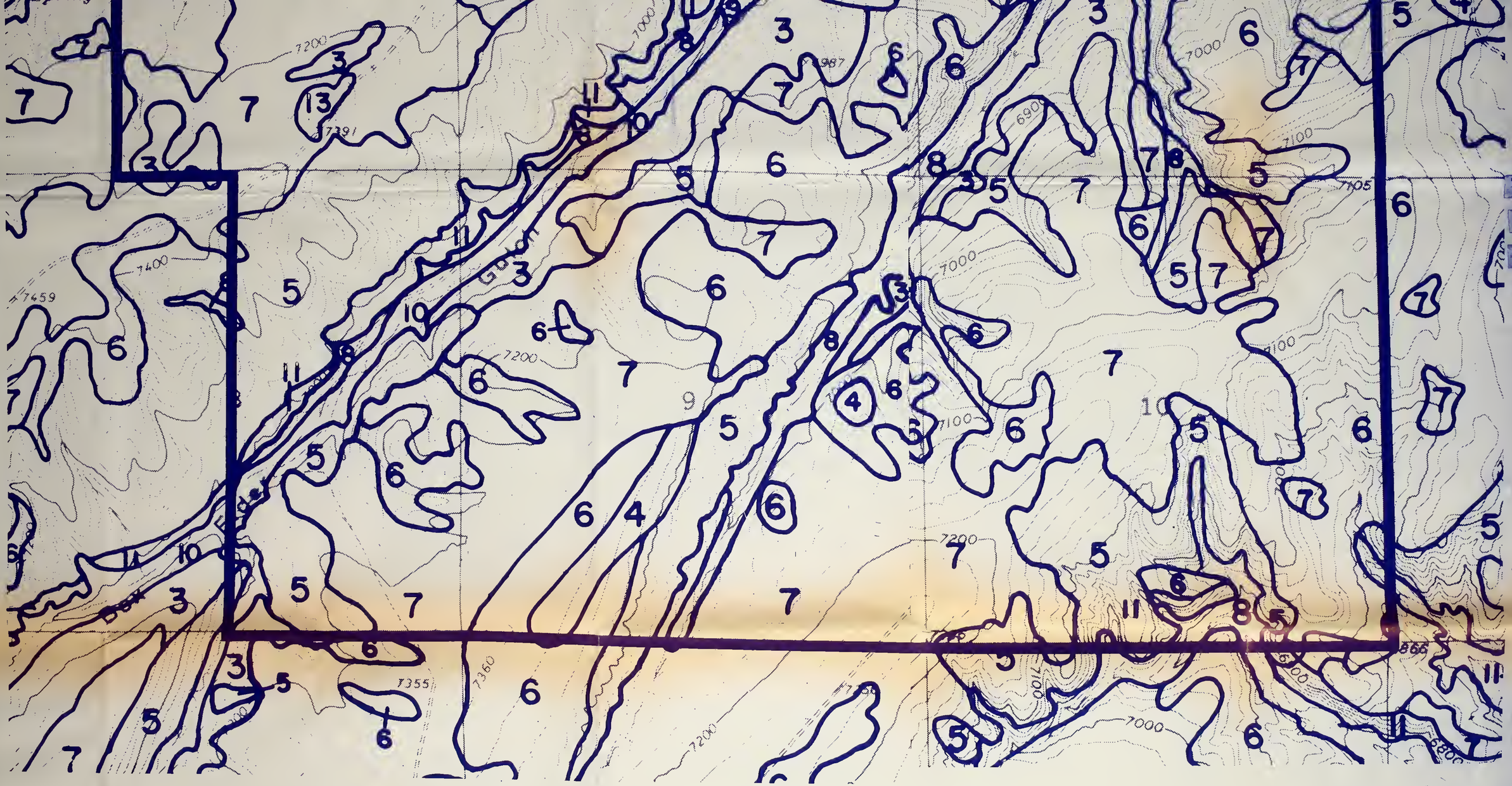
FILE: J-10

R 99 W

TRACT C-a

MDP MINING & PROCESSING FACILITIES

T 1 S



0 2500

FEET

1"=500'

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
RIO BLANCO OIL SHALE PROJECT

HABITAT TYPES

1 DOUGLAS FIR	6 PINYON-JUNIPER SAGEBRUSH	11 SHADSCALE
2 ASPEN	7 UPLAND SAGEBRUSH	12 RIPARIAN
3 MIXED BRUSH	8 BOTTOMLAND SAGEBRUSH	13 BALD
4 PINYON-JUNIPER	9 RABBITBRUSH	14 AGRICULTURE
5 PINYON-JUNIPER MIXED BRUSH	10 GREASEWOOD	

RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO

TRACT C-a
PRESENT VEGETATION

DRAWN BY:	SCALE: 1"=500'	FIGURE C-4
DESIGN BY:	DATE: 9/14/77	
APPROVED BY: PWM	DRAWING NO:	

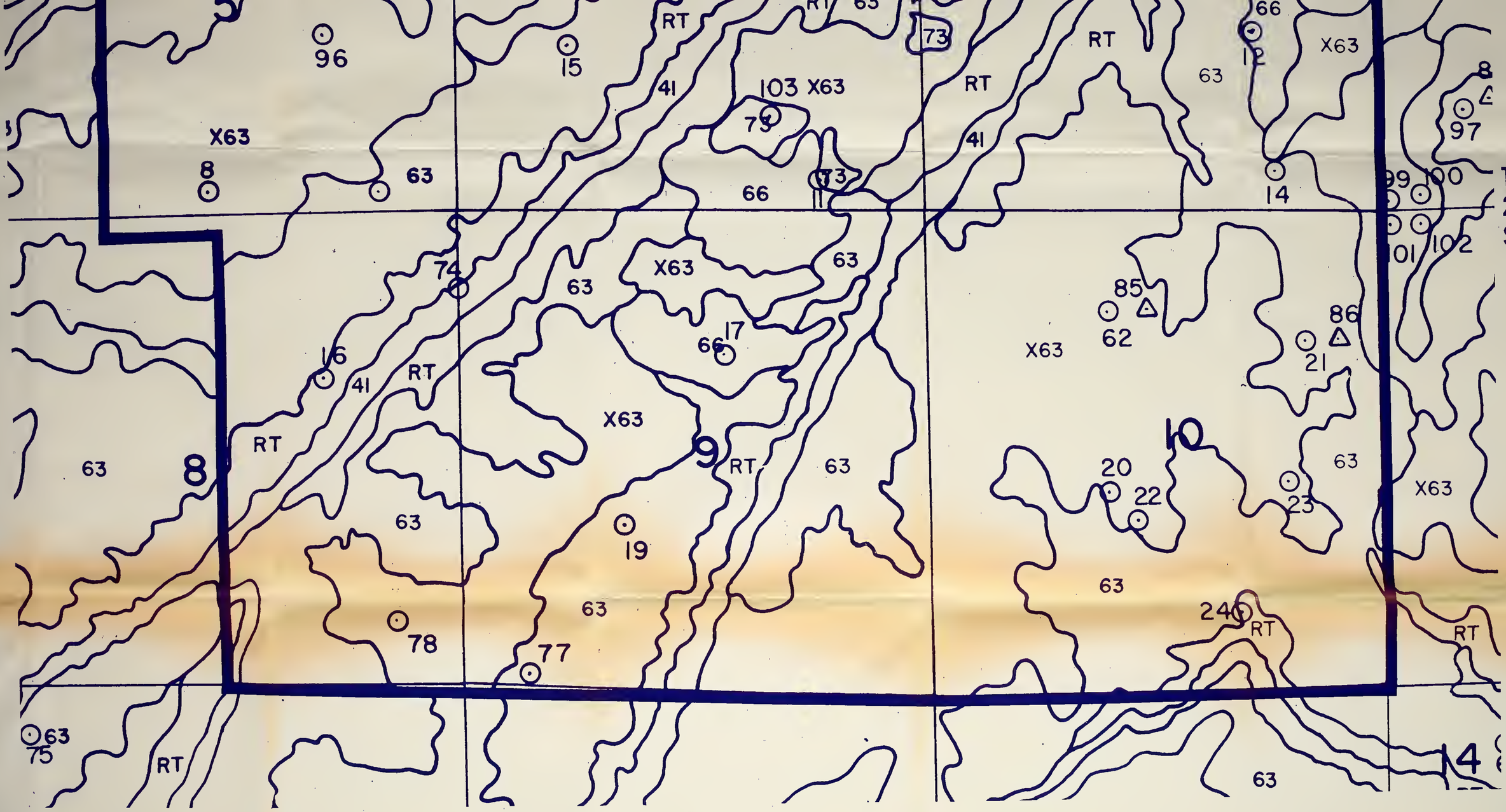
FILE: K-12

R 99 W

TRACT C-a

MDP MINING & PROCESSING FACILITIES

T 1 S



0 2500
FEET

LEGEND FOR SOIL SERIES

38	HAVRE	66	REDCREEK-RENTSAC COMPLEX
41	GLENDIVE	73	YAMAC
61	CASTNER	75	RIVRA
	RENTSAC	RT	ROCK OUTCROP-TORRIORTHENT COMPLEX
		X63	RENTSAC-PICEANCE COMPLEX

RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO

SOIL TYPES

DRAWN BY:	SCALE: 1"=500'	FIGURE C-5
DESIGN BY:	DATE: 9/14/77	
APPROVED BY: PWM	DRAWING NO	
	FILE:	

R 99 W

TRACT C-a

MDP MINING & PROCESSING FACILITIES

T 1 S

0 2500

FEET

1"=500'

RIO BLANCO OIL SHALE PROJECT

RIO BLANCO COUNTY, COLORADO

TOPSOIL DEPTH IN CENTIMETERS

DRAWN BY:	SCALE: 1"=500'	FIGURE C-6
DESIGN BY:	DATE: 9/14/77	
APPROVED BY: PWM	DRAWING NO:	

FILE A-12

CHAPTER 1
INTRODUCTION

1.1 SCOPE

This Section presents the conceptual design of a processed shale storage facility for the Lurgi demonstration plant to be constructed and operated on the RBOSC off-tract property adjacent to Tract C-a. The location of project site is shown on Figure 1-1-4. The principal purpose of the design is to provide a processed shale disposal system which will minimize impacts to the environment. The disposal system is designed to demonstrate proposed technology and to collect pertinent data which will be helpful in optimizing the operation for the processed shale disposal system for the commercial operation. The selected design is considered to be the most cost effective means of accomplishing these objectives.

1.2 PROJECT BACKGROUND

The requirements for the Lurgi Demonstration Project include the disposal of overburden from an open pit and of processed oil shale from the Lurgi demonstration plant. The Lurgi Demonstration Project will be carried out in two phases at a production rate of 4,400 tons of raw ore per day. A disposal facility is required for a total of three million tons of processed shale for the two phase operation. Associated with the two phases will be the excavation of an estimated total of 9.4 million bcy of overburden material. This material is available for use as a construction material for haul roads, for processed shale disposal facilities and for open pit backfilling. A portion of the overburden will be low-grade ore and will either be stockpiled or utilized in such a way that it can be recovered in the future.

This discussion sets out the concepts and design of the overburden/low-grade ore/processed shale disposal facility for the Lurgi Demonstration Project. Disposal planning and conceptual design for processed shale are presented in Chapter 2. Topics addressed include:

- Characteristics of processed shale

- Design criteria
- Site selection and preparation
- Disposal material conditioning and transport
- Major structures and civil works
- Reclamation
- Water management
- Dust control

Chapter 3 is a description of the overburden waste disposal operation including the estimated quantity of overburden generated by each phase of mining development.

Chapter 4 presents proposed demonstration and data collection programs related to processed shale disposal. The objectives of these programs are to demonstrate proposed technology and to acquire sufficient data for optimizing the design and operation of a commercial system. The arrangement of programs is designed to coordinate with the proposed mining and retorting production schedules, beginning with Phase I mine development and extending through Phase II operations. The scope of the programs covers the various environmental and mining operational aspects such as:

- Materials handling
- Stability of waste
- Leachate quality
- Reclamation
- Erosion
- Dust Control

CHAPTER 2

PROCESSED SHALE DISPOSAL OPERATION

2.1 DESIGN CRITERIA

The disposal plan for the processed shale was designed to comply with the following regulations:

- Colorado Mined Land Reclamation Rules and Regulations, amended June 1978 (as per Colorado Mined Land Reclamation Act, 1976)
- Regulations for Solid Waste Disposal Sites and Facilities (as per Subtitle D-RCRA), Colorado Department of Health
- Tract C-a Oil Shale Lease
- NPDES (National Pollution Discharge Elimination System), Colorado Department of Health and U.S. Environmental Protection Agency
- Rules and Regulations for Plans and Specifications for the Construction of Reservoir Dams, Division of Water Resources, Office of the State Engineer of Colorado
- Prevention of Significant Deterioration (PSD), Total Suspended Particulate (TSP), limitations (as per 1977 Clean Air Act Amendments), U.S. Environmental Protection Agency

At the proposed production rate of 4,400 tons per day of raw shale the estimated processed shale quantity for disposal is 1.2 million tons for Phase I operation and 1.8 million tons for Phase II operation. The required disposal volume was determined using an estimated density of 65 pounds per cubic foot uncompacted and a moisture content of 15% to 20% by weight. Therefore, the total processed shale volume would be 1.37 million cubic yards for Phase I and 2.05 million cubic yards for Phase II operation.

Processed shale disposal operations for Phase I have been planned to meet initial disposal requirements and to accommodate Phase II requirements. Phase II processed shale disposal operations are presented in more general terms outlining design concepts and will be capable of modification to take advantage of the experience obtained in Phase I. As demonstration and

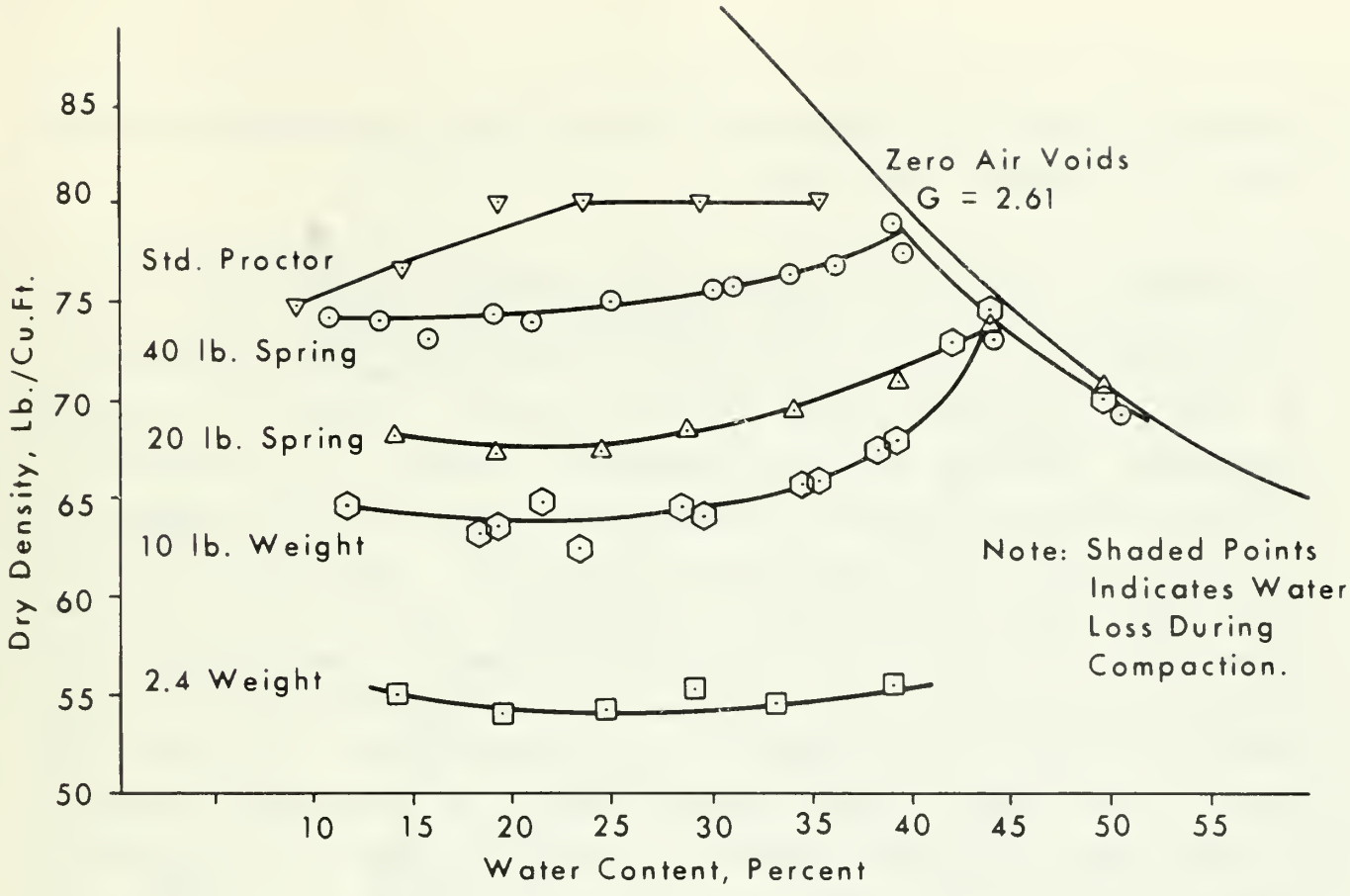
testing programs are completed on the disposal facility in both Phase I and Phase II, it will be progressively reclaimed and revegetated.

2.2 CHARACTERISTICS OF LURGI PROCESSED SHALE

A. General - Until the Lurgi demonstration plant is constructed and operating, the characteristics of the processed shale will not be completely known. However, its characteristics have been anticipated from laboratory studies on material obtained from Lurgi test runs made in 1976. This material was composed of an approximately 50:50 mixture of materials collected from a cyclone and an electrostatic precipitator and was from a run which had a burn temperature and duration comparable to those anticipated in the demonstration plant. Prior to the addition of moisture the material is in the form of a dark grey, fine powder. With the addition of water the processed shale becomes quasi-plastic and with time develops into a relatively strong and impervious material. Results of laboratory tests carried out to date are summarized below.

B. Index Properties - The processed shale is made up of irregular grains and has a specific gravity ranging from 2.61 to 2.68. Mineralogical analyses by Colorado School of Mine Research Institute (CSMRI) using x-ray diffraction indicate that the material is composed of approximately 36% $CaCO_3$ and 33% SiO_2 with the balance split more or less equally between ($CaCO_3$ $MgCO_3$) and (Na, Ca) Al (Si, Al) Si_2O_8. The size gradation of the material is mainly in the silt range and Atterberg limit determinations indicate the material to be nonplastic prior to moisturizing (Figure 5-2-1). Also shown on Figure 5-2-1 are the compaction characteristics of the processed shale. These show the effects which moisture content and compactive effort have on the densities which can be achieved with this material. The achieved densities are relatively insensitive to the amount of water, particularly in the lower ranges of moisture content.

Standard Proctor dry density, which is comparable to the low range of what might be expected using conventional construction compaction equipment in the field, is of the order of 80 pcf. Achieved densities drop off substantially with lower compactive efforts. By contrast, the maximum density which can be



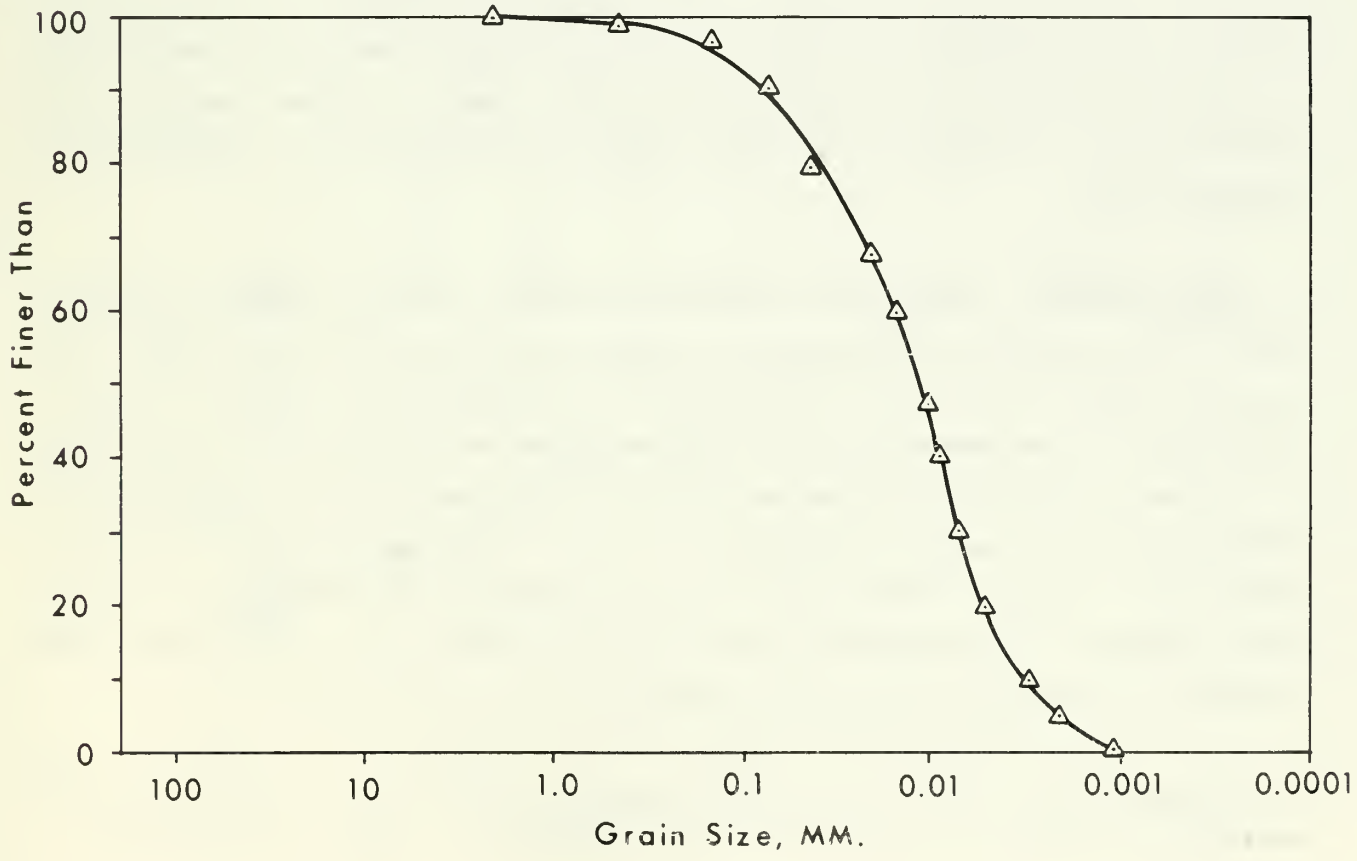


Figure 5-2-1

Laboratory Compaction Test Results RBOSC
Processed Oil Shale - Harvard Miniature

achieved by vibration of dry material averaged 69 pcf; corresponding minimum density for dry material was 42 pcf.

C. Strength - Preliminary testing of the strength characteristics of the Lurgi processed shale has been carried out. From previous work, it was anticipated that in addition to moisture content and density, the variables of time and temperature might have an important influence on strength development. Choosing unconfined compressive strength as an indicator of strength, cylindrical samples for testing were formed at moisture contents of 15%, 20% and 67%, the latter being a 60-40 slurry. These were cured under humid conditions at temperatures of 35°F, 70°F and 150°F and tested at various times. The results of the tests are shown on Figures 5-2-2, 5-2-3 and 5-2-4 and indicate clearly that both time and temperature have important effects on strength development for the material tested. The data also indicates that the processed shale is capable of developing significant strength under the right conditions, probably by some sort of chemical cementing action, but further work will be required to determine the practical implications of the data. As a further indication of the long term strength of the material, a series of drained triaxial tests were carried out at 20% moisture and in a 60:40 slurry. The results of these suggest that conditions are favorable for the long term stability of the material (Figure 5-2-5).

D. Consolidation - Preliminary laboratory study of the consolidation properties of the processed shale has also been carried out and the results are shown on Figure 5-2-6. As in the case of the strength, the effect of time is significant in determining consolidation characteristics. For curing times of 14 and 29 days, the compressibility of the material is substantially reduced up to an applied pressure of 3 to 4 tons per square foot (tsf). Above this pressure compressibility is essentially similar to a freshly placed sample. This apparent preconsolidation effect, as in the case of the strength, is probably due to a cementing action.

E. Permeability - Laboratory tests have been carried out to determine the permeability (hydraulic conductivity) of the material. Again, a time effect

Samples Compacted With Harvard Miniature, 40 lb. Spring, 15% Water Content.

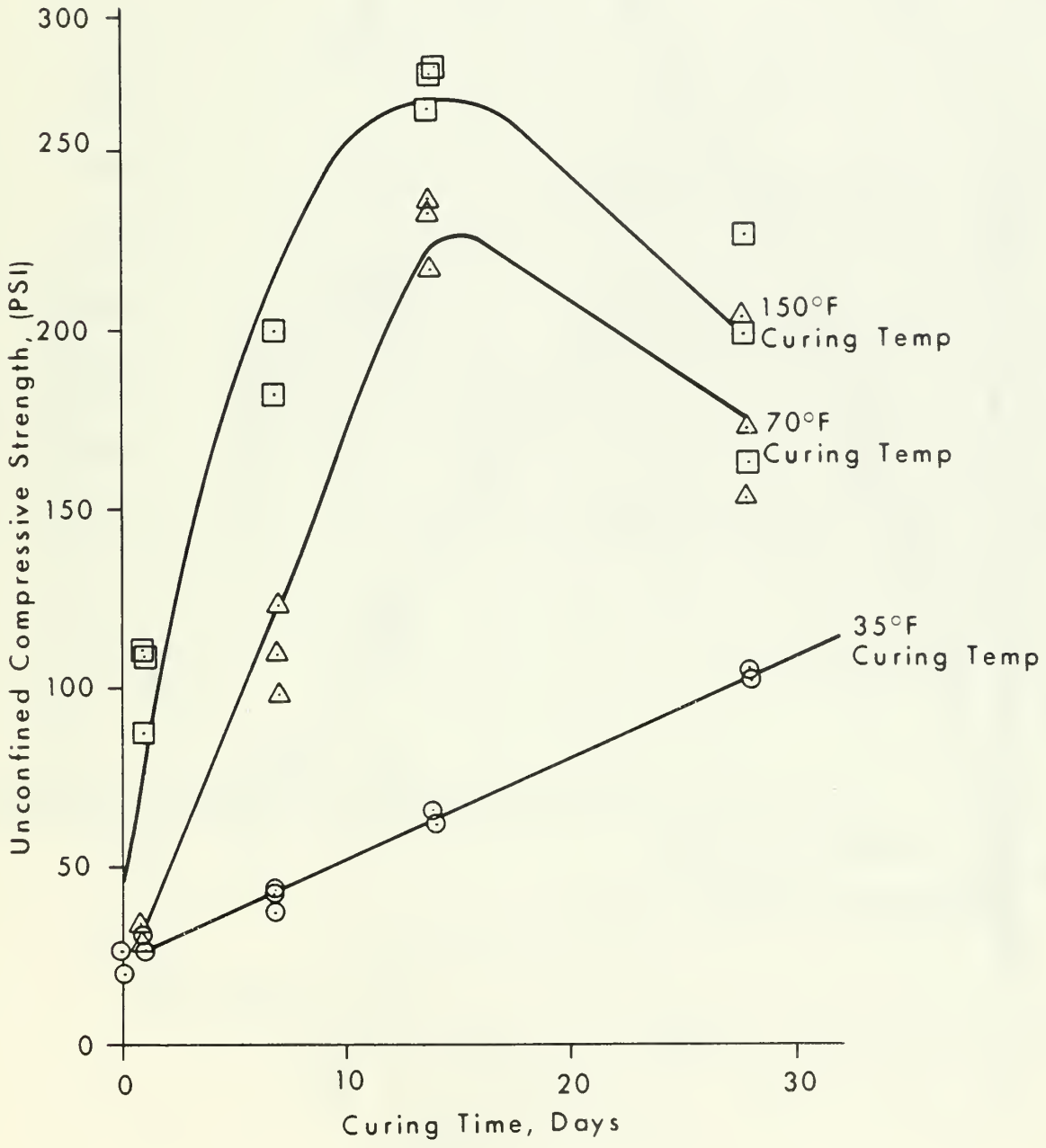
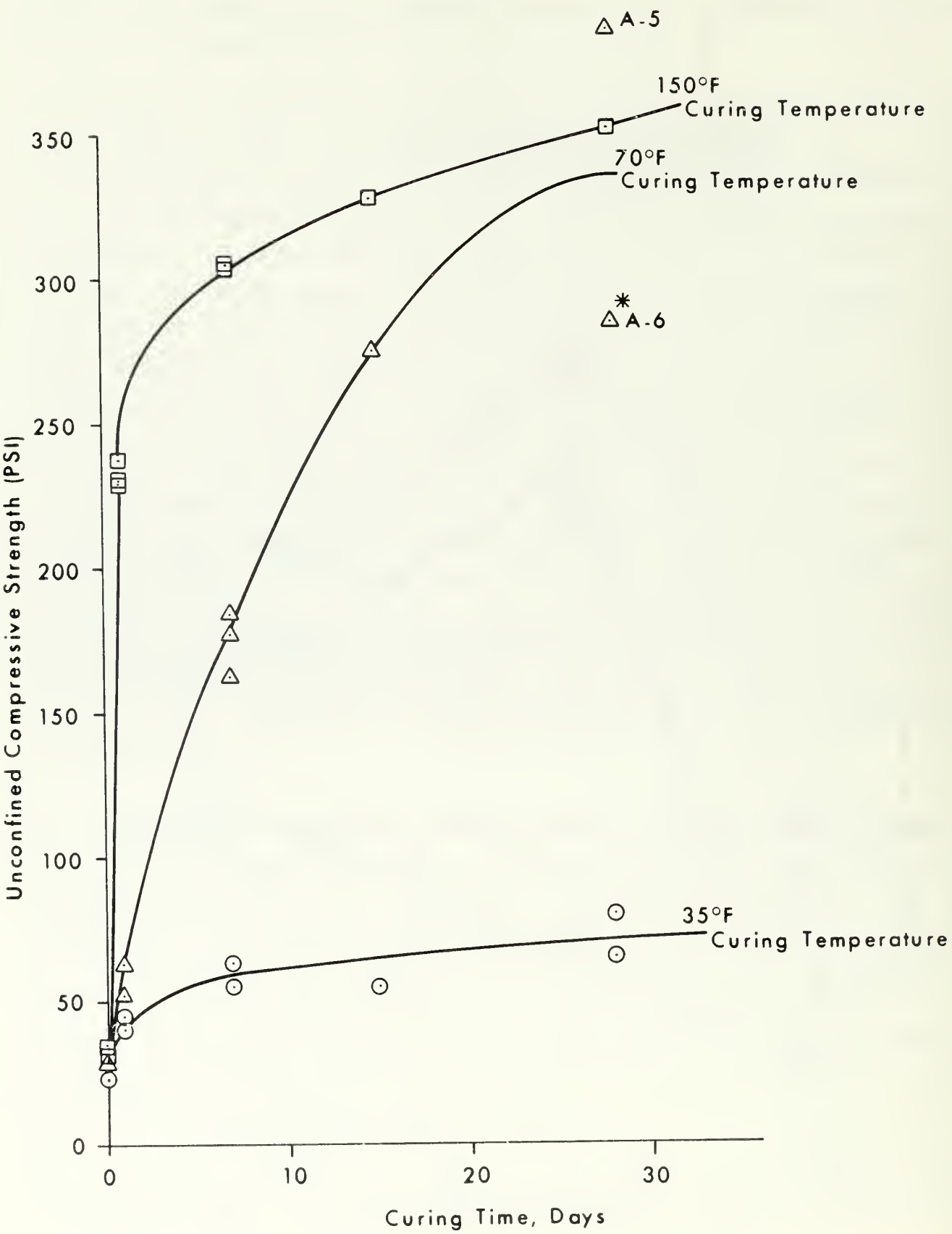


Figure 5-2-2
Unconfined Compressive Strength vs. Curing Time - RBOSC Processed Oil Shale



* Top Damaged

Figure 5-2-3

Unconfined Compressive Stength vs. Curing Time -
RBOSC Processed Oil Shale

Slurry Mixture

60% Solids

40% Water

Samples Formed in Molds and Removed as Soon as Adequate Strength Had Been Achieved

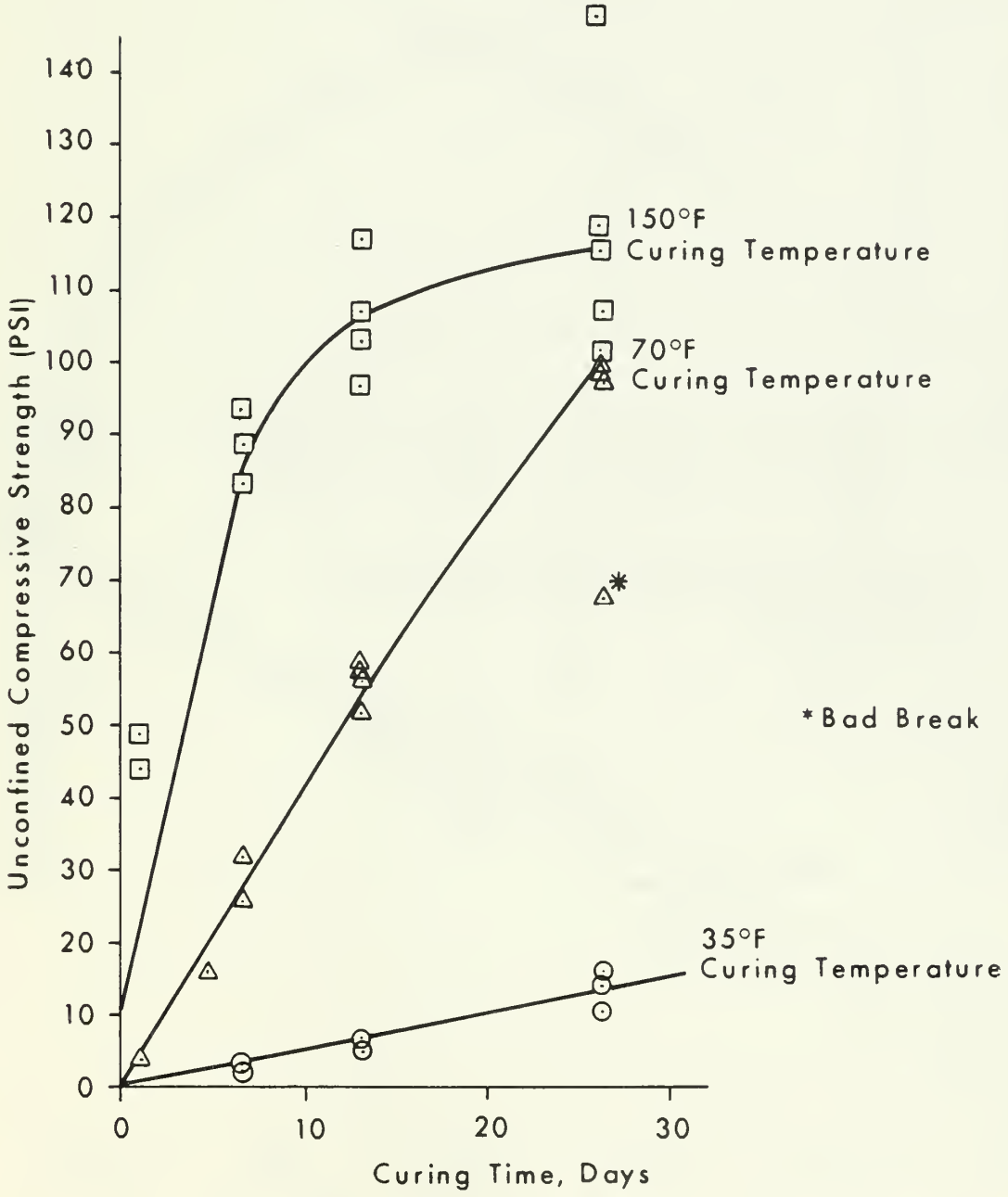


Figure 5-2-4

Unconfined Compressive Strength vs. Curing Time - RBOSC Processed Oil Shale

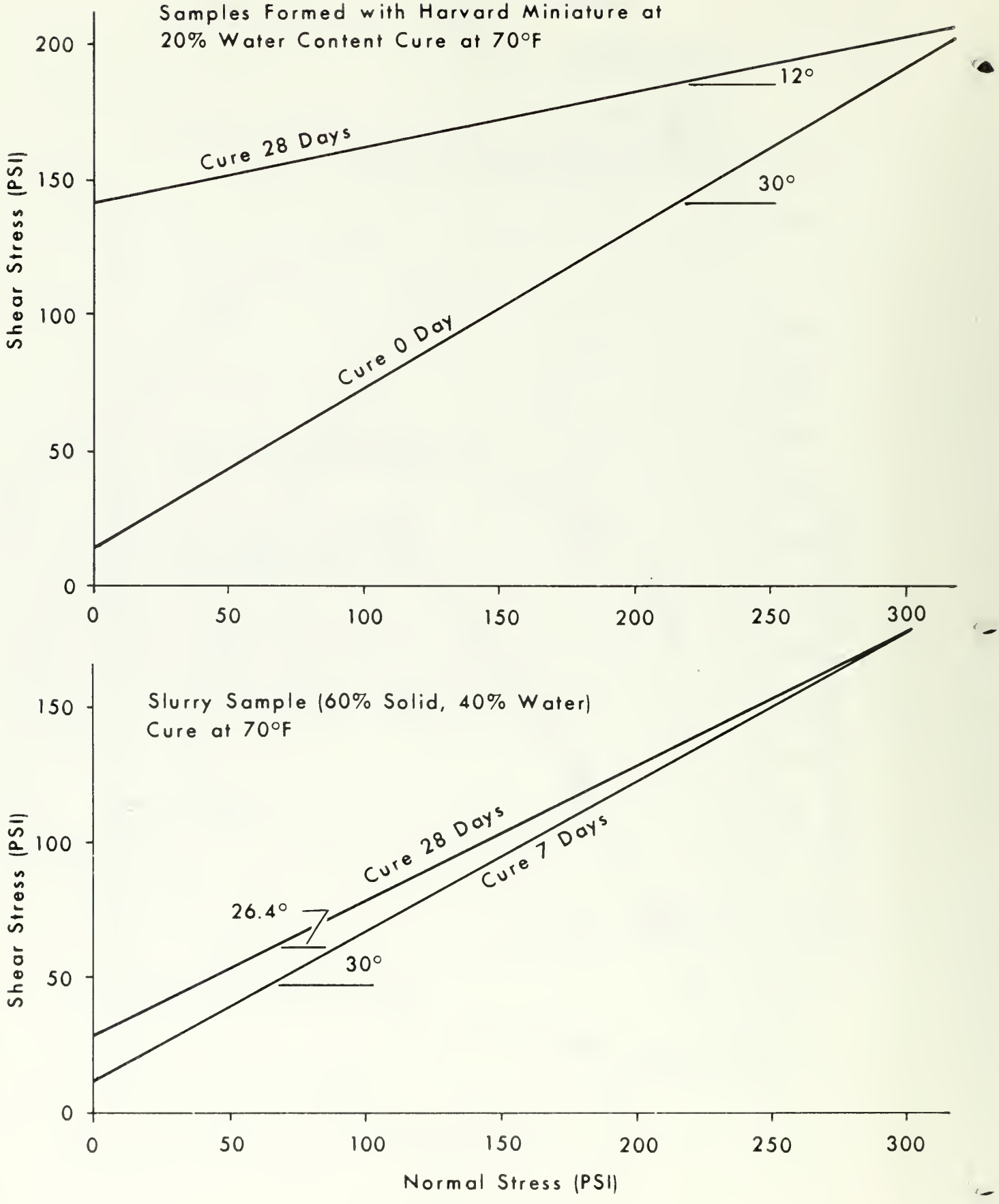


Figure 5-2-5
Triaxial Test Consolidated Drained Unsaturated

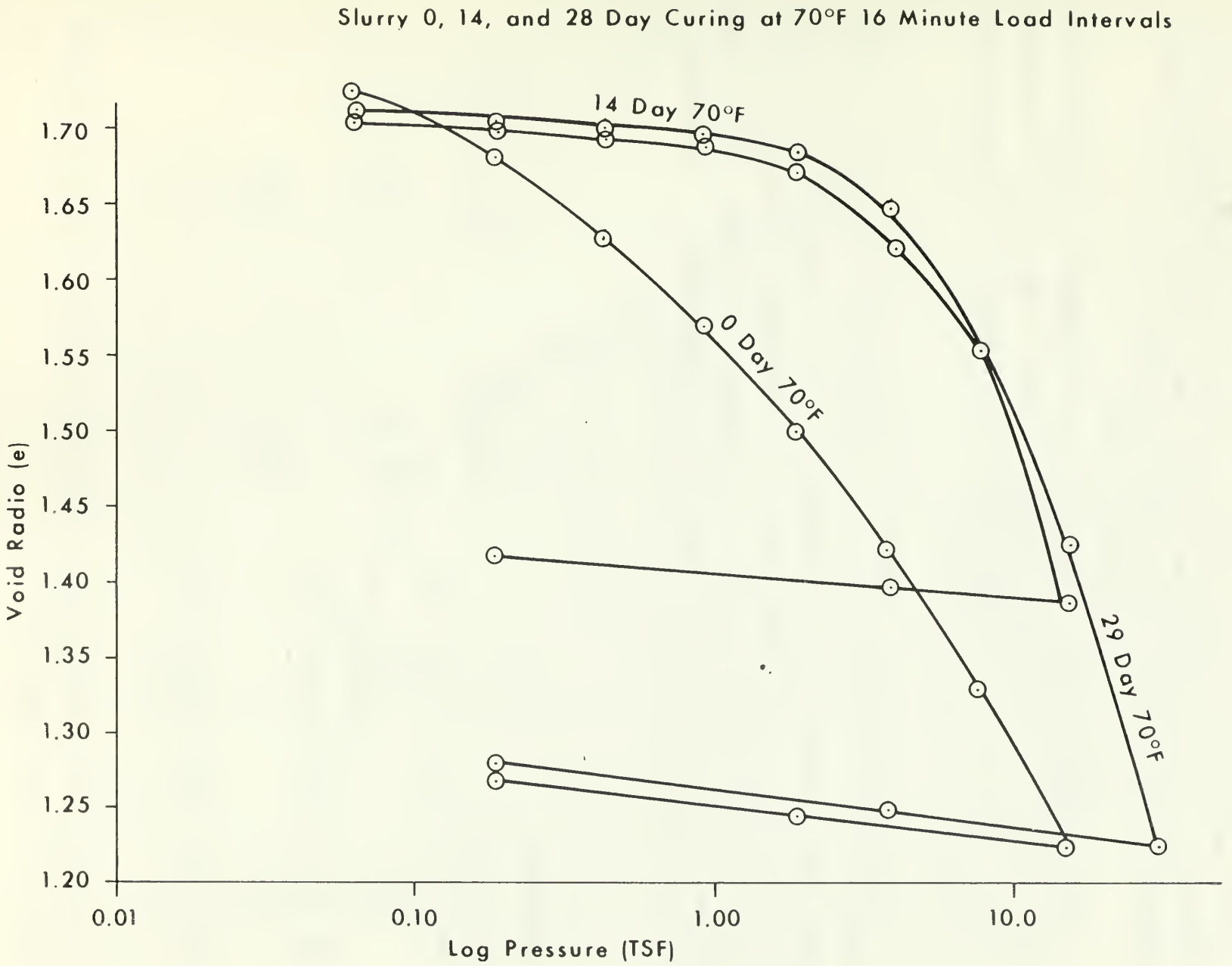


Figure 5-2-6
Consolidation Tests Void Ratio vs. Log Pressure

has been noted as shown in Figure 5-2-7, which gives the results of permeability determinations made over a period of time in a single sample. A drop in permeability of an order of magnitude from $k = 4 \times 10^{-5}$ to $k = 3 \times 10^{-6}$ cm/sec was observed, confirming similar results obtained by AMOCO Laboratories. Work by CSMRI has suggested that this measured decrease in permeability may be due to crystal growth in the pores.

F. Angle of Repose - Angle of repose is not a fundamental engineering property, but it is a parameter frequently used in the design of disposal systems. Laboratory tests indicate that for dry material, the average angle of repose will vary between 38° and 41°.

G. Slurry Characteristics - Preliminary rheology studies have been carried out by CSMRI to determine the characteristics of the processed shale in slurry form, because this is a potential means of transporting this waste from the retort to the disposal facility. These studies indicated that the slurried processed shale behaves as a non-Newtonian fluid and that the Bingham plastic model provided a good fit to the experimental flow behavior. Flow constants derived from this model were as follows:

Slurry Concentrate (Wt % Solids)	Slurry Sp. Gr.	Yield Stress (dyne/cm^2)	Plastic Viscosity (dyne sec/cm^2)
Temp. 80°F; 0.425 inch diam. tube			
57.9	1.570	277.03	1.196
52.2	1.486	38.36	0.297
43.1	1.370	3.28	0.105
Temp. 80°F; 0.815 inch diam. tube			
57.9	--	355.46	0.928
52.2	--	39.00	0.297
43.1	--	4.81	0.159
Temp. 180°F; 0.425 inch diam. tube			
52.5	1.490	55.64	0.165

It was concluded that the optimum slurry for minimal viscosity and yield stress would contain about 40% solids.

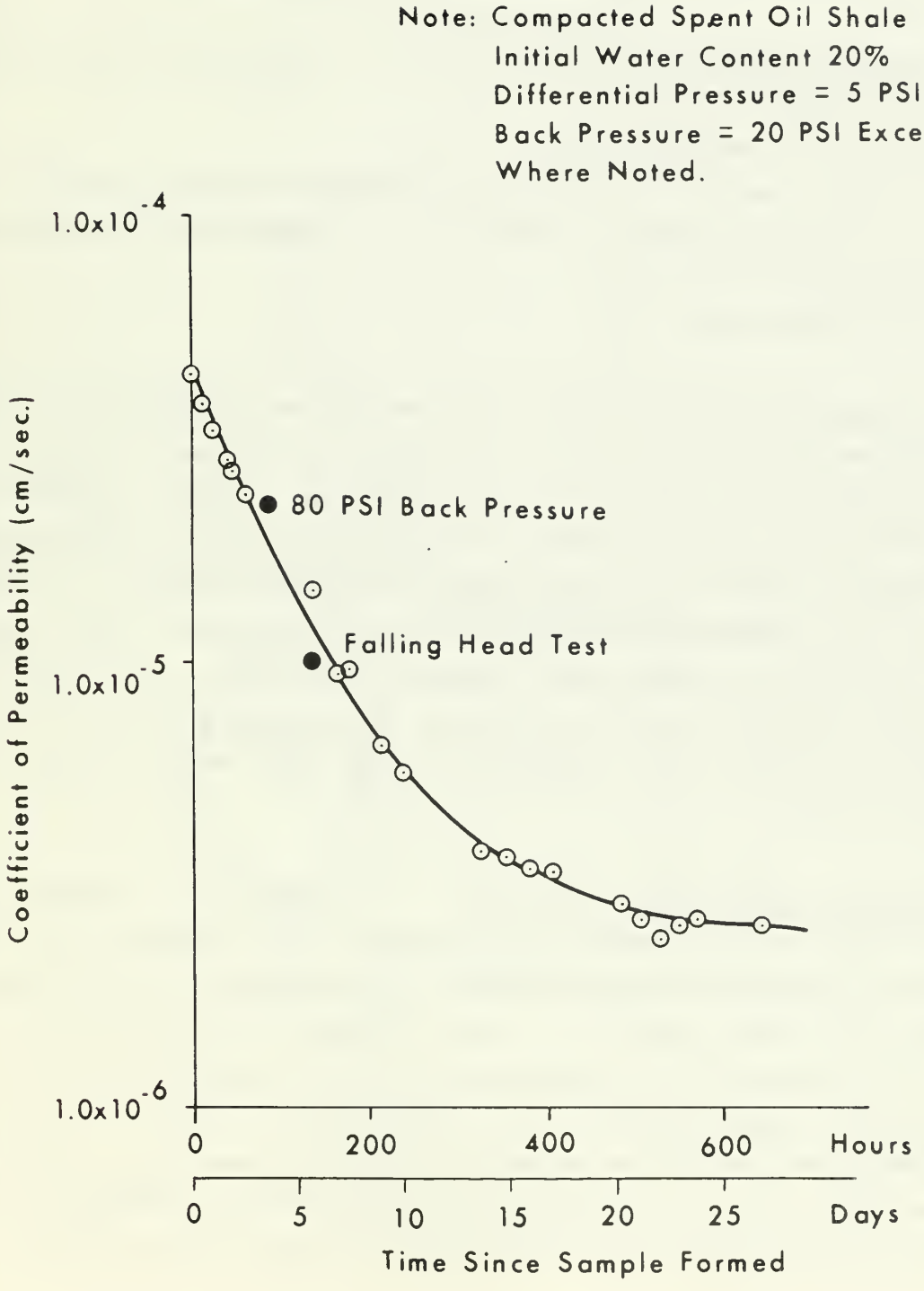


Figure 5-2-7
Coefficient of Permeability vs. Sample Curing Time

2.3 SITE SELECTION

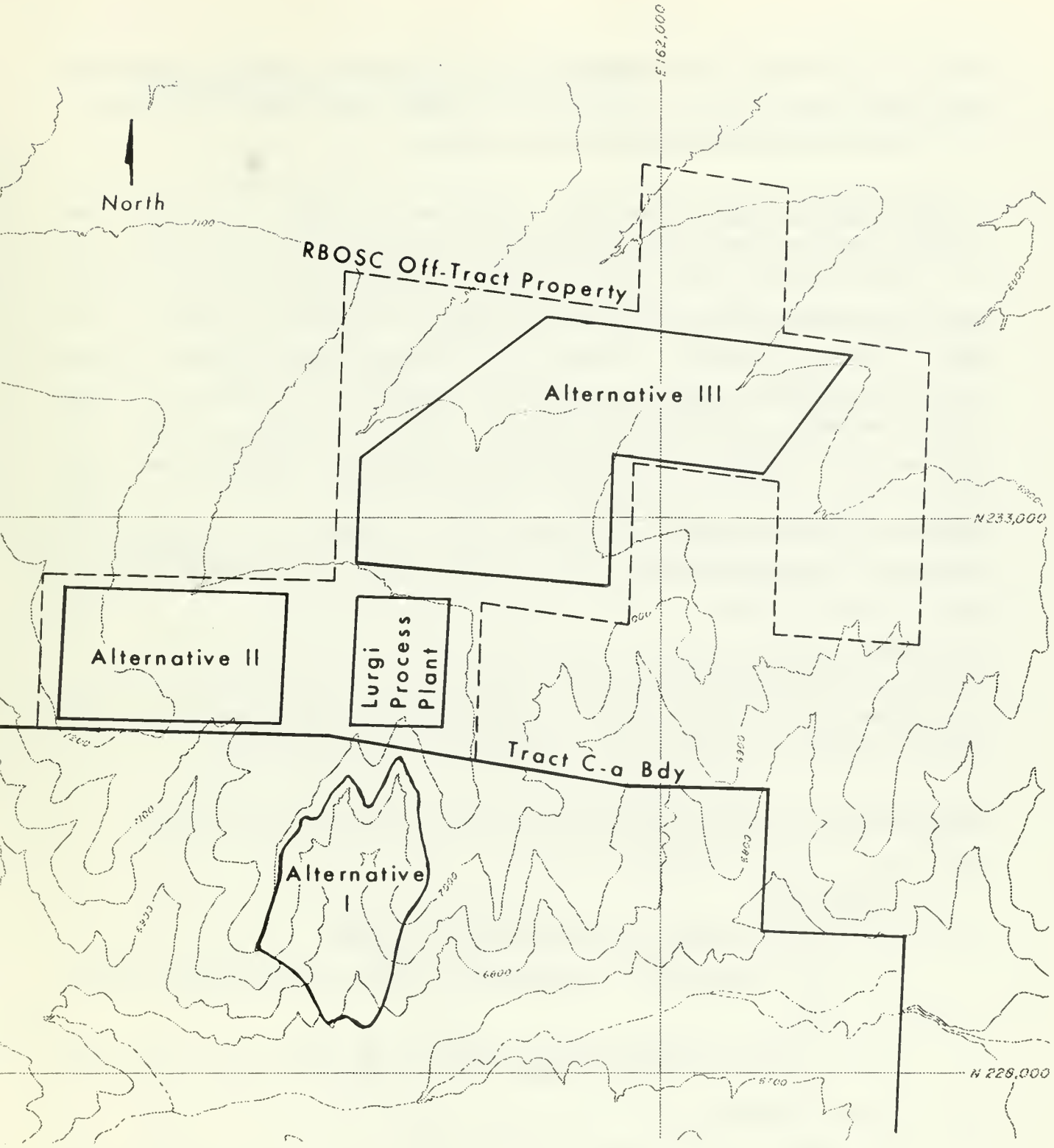
The selection of the site for the test processed shale facility involved a number of steps from original concept to final choice. This section sets out the main criteria of choice and the evolution of the site concept. The site alternative areas and site contours are shown in Figure 5-2-8.

A. Site Selection Criteria - The criteria for site selection and facility design were, in order of importance:

- Environmental acceptability
- Ability to perform experiments and collect data which would aid in optimizing the design and operation of a commercial scale processed shale disposal facility
- Cost effectiveness

B. Valley Disposal (Alternative I) - The first system of disposal considered was a head of valley fill in the draw to the south of the Lurgi process area. This is a conventional solution to disposal, and has a number of permitting, experimentation, and cost advantages. After consideration, it was decided that although this might be the least expensive disposal option, it would not allow much of the important experimentation to be performed. The irregular thickness of the pile would make leachate, compaction, and revegetation demonstrations difficult, and the collection of leachate at the base of the pile, which is an important experimental design goal, would be almost impossible.

C. Dual Disposal System (Alternative II) - In order to overcome these problems, a dual disposal option was evaluated, with a temporary test dump being set up in the westernmost section of the RBOSC off-tract property. The valley fill would then be the final disposal site for all processed shale, but the important test work would be done on a separate 20 acre plot. This solution has some attraction from a demonstration point of view, but is less attractive because of the increase in disturbed land area, and because of previous plans for use of the test area for raw shale stockpile. Also, the surface area available for experimentation was somewhat small for the



Note:
Scheme II Disposal System is a Dual Disposal System Including Sites of Alternatives I & II North

Figure 5-2-8
Locations of Alternative Spent Shale Sites

number of experiments and demonstrations contemplated. Finally, the double handling of the shale incurs considerable expense, and would delay revegetation of the final processed shale disposal area.

D. Mesa Disposal (Alternative III) - Based on the above, it became clear that an ideal site from the point of view of experimentation would be a site on a large relatively flat piece of land. The most attractive nearby location is a broad ridge or mesa running through the central portion of the RBOSC off-tract property. However, this processed shale disposal concept posed some potential permitting problems, because of the likely increased erosion potential, exposure to wind, and possible stability problems. To overcome these problems it was decided to incorporate the processed shale disposal system into the overburden stockpile in such a way as to completely enclose the processed shale with placed rock enbankments. A balance of the processed shale and overburden suggested that this would provide an excellent final disposal facility.

A further permitting problem is the interruption of watercourses. This can be overcome on this site by some minor diversion and collection of all runoff from the facility in channels which discharge to a settlement pond.

The attractions of final disposal on the mesa in this way are as follows:

1. Permitting
    - Erosion of processed shale can be eliminated
    - Overall stability is independent of the processed shale properties
    - Relatively impermeable strata (10^{-5} cm per sec)
    - Revegetation demonstrations and experiments can start early in the project
    - Runoff can be collected and controlled
    - Stripping and stockpiling of topsoil is easy and topsoil is easily available for revegetation
    - There is limited interruption to topography and drainages
    - Depth to ground water is substantial (450-500 feet)

2. Experimentation and Demonstration Program

- The area lends itself to a relatively constant thickness of processed shale which aids collection and interpretation of leachate data
- Leachate can be collected and analyzed in separate compartments
- Parts of the surface of the dump become available for experimentation early in the project
- The experimental revegetation of the pile can become the final revegetation depending on results
- Different research efforts can take place in different areas at the same time (e.g., leachate, vegetation, compaction, slurry disposal, erosion, and slope stability)

E. Conceptual Design - Based on the above discussions, a mesa disposal system for the processed shale containment facility was selected. The fundamental design concepts used are as follows:

- The processed shale will be entirely contained by wide stable rock berms constructed of overburden from the mine to eliminate potential stability and erosion problems.
- During construction and operation, the rock berm areas will drain to a single sedimentation pond to control turbidity.
- During construction and operation, the processed shale surface runoff will be contained within the water management system (a zero discharge of contaminants concept).
- All leachate from the Phase I processed shale facility will be collected and representative samples will be analyzed.

The layout of the facility is shown on Figure 5-2-9.

The sequence of activities which will be used to develop the processed shale containment facility is as follows:

1. Construction of Containment Facility Dikes - Dikes for the containment facility will be constructed of excess material from the haul road construction and of overburden from the open pit mine. Wide berms with 3:1

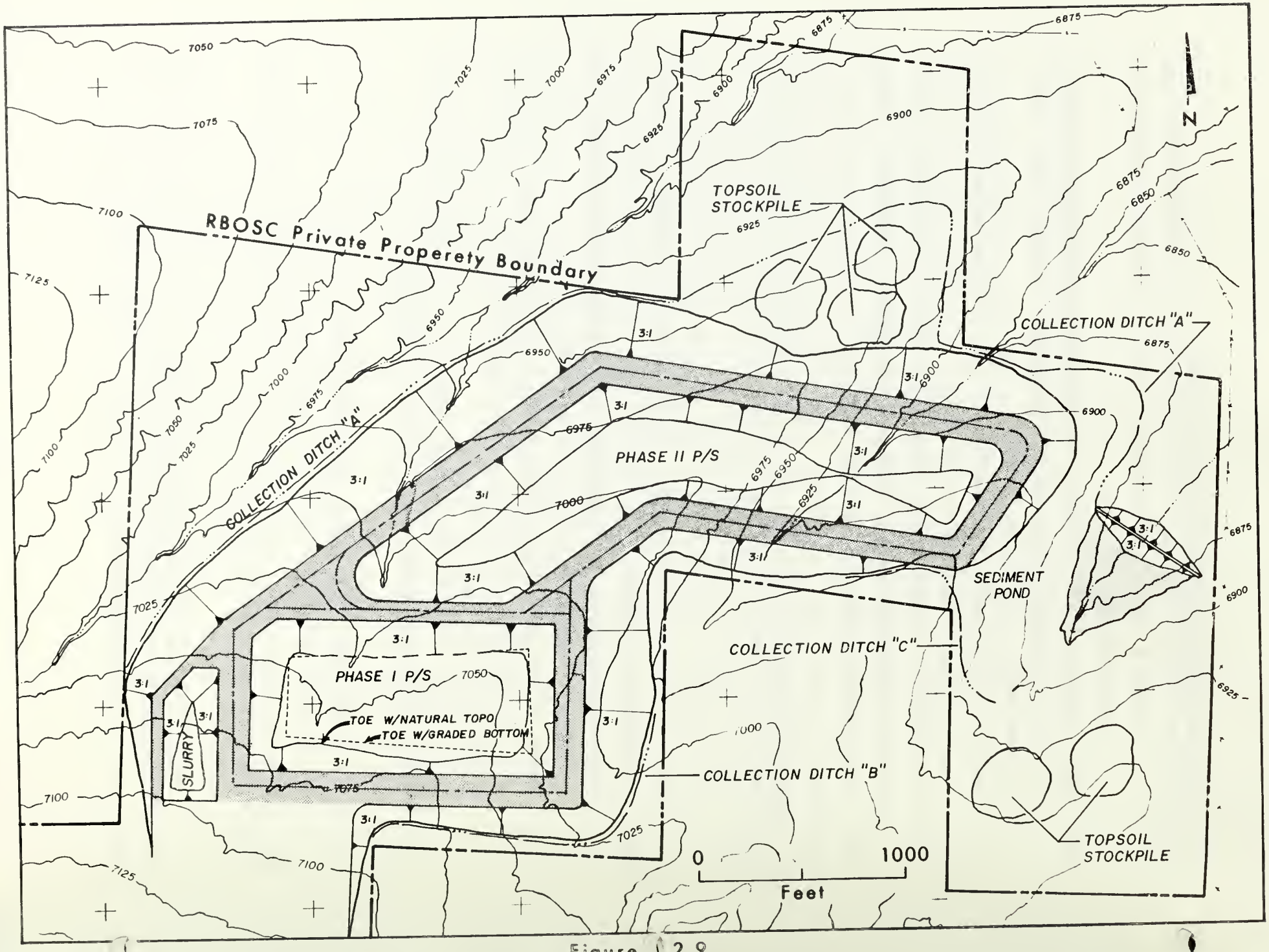


Figure 12-9
Processed Shale Disposal System

external slopes ensure a high degree of stability and erosion protection. Significant portions of the overburden constitute low grade oil shale and as such will be classified and placed in defined areas for possible future exploitation.

2. Construction of Leachate Collection System - The Phase I processed shale containment areas will be provided with a total leachate collection system as part of the research design. This comprises a synthetic liner with a filter blanket laid over it. The filter blanket will be comprised of clean washed sand or gravel which will eliminate its potential for altering the chemistry of any leachate which may pass through it. In addition, small berms will be placed in the liner bedding material to segment the lined area, and a system of collector pipes will direct any leachate to individual collector sumps located at the low point of the facility where the leachate will be measured and analyzed.

3. Construction of Leachate/Revegetation Test Area - The initial processed shale dumping will take place at the ends of the Phase I containment area. The material will be transported from the retort by conveyor and dumped by a stacker in relatively thin layers over the full height of the face. The dumping will take place until there is enough surface area for a revegetation plot area, a flooded induced leaching area, and a leachate control area, plus associated buffers between each. As soon as these areas are complete, the revegetation and leachate demonstrations and research will begin. Prior to and during the revegetation period, wind erosion data of uncovered processed shale will be collected.

4. Slope Stability and Erosion Test Area - The faces of the above areas will be used to perform erosion and slope stability tests on the processed shale material at different slope angles.

5. Compaction Test Area - The central portion of the Phase I area will be used to carry out demonstrations of the compaction of the processed shale. The material will be placed and compacted in horizontal lifts and the mechanical and leachate behavior of compacted processed shale will be studied.

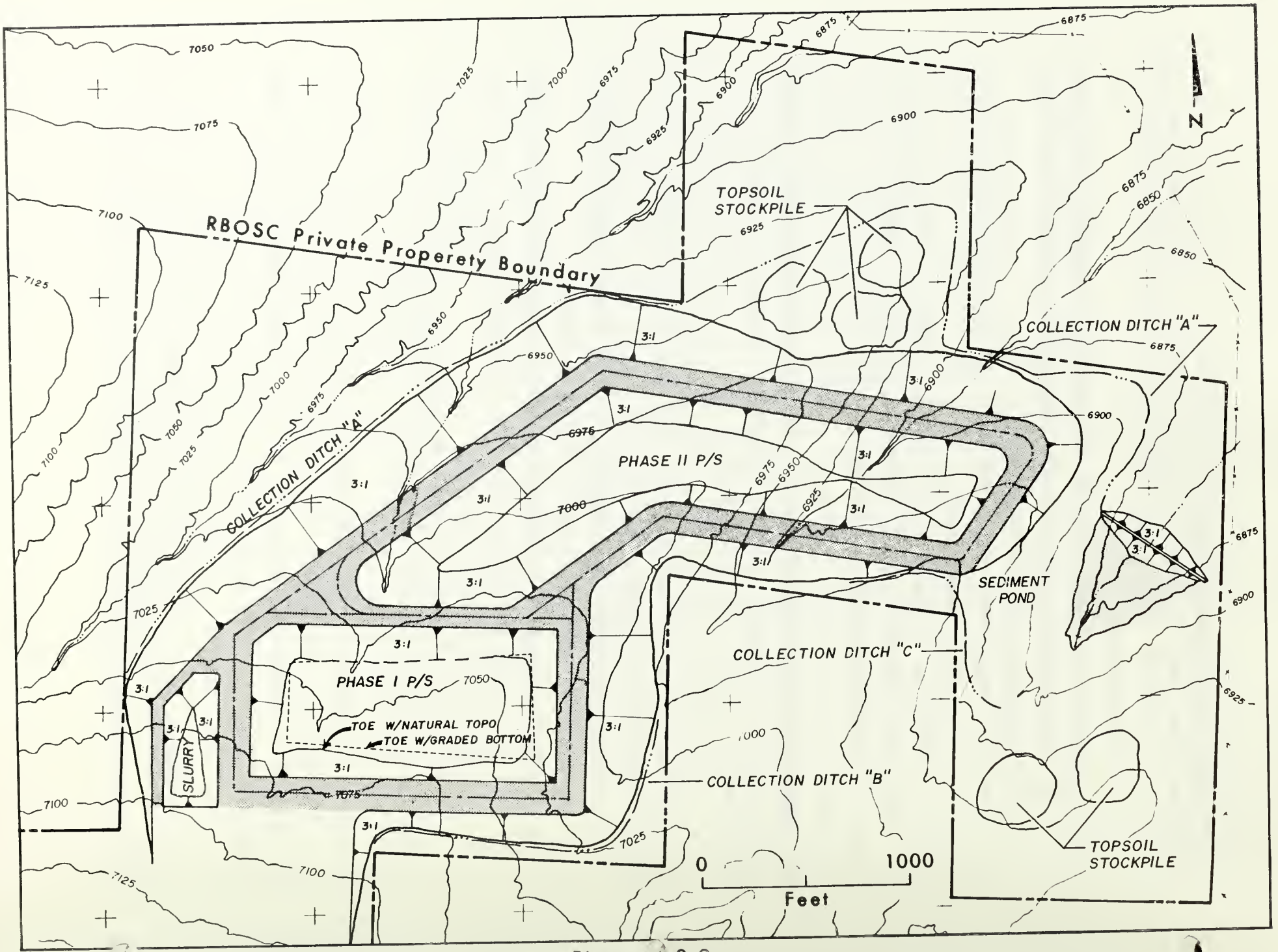


Figure 12-9
Processed Shale Disposal System

external slopes ensure a high degree of stability and erosion protection. Significant portions of the overburden constitute low grade oil shale and as such will be classified and placed in defined areas for possible future exploitation.

2. Construction of Leachate Collection System - The Phase I processed shale containment areas will be provided with a total leachate collection system as part of the research design. This comprises a synthetic liner with a filter blanket laid over it. The filter blanket will be comprised of clean washed sand or gravel which will eliminate its potential for altering the chemistry of any leachate which may pass through it. In addition, small berms will be placed in the liner bedding material to segment the lined area, and a system of collector pipes will direct any leachate to individual collector sumps located at the low point of the facility where the leachate will be measured and analyzed.

3. Construction of Leachate/Revegetation Test Area - The initial processed shale dumping will take place at the ends of the Phase I containment area. The material will be transported from the retort by conveyor and dumped by a stacker in relatively thin layers over the full height of the face. The dumping will take place until there is enough surface area for a revegetation plot area, a flooded induced leaching area, and a leachate control area, plus associated buffers between each. As soon as these areas are complete, the revegetation and leachate demonstrations and research will begin. Prior to and during the revegetation period, wind erosion data of uncovered processed shale will be collected.

4. Slope Stability and Erosion Test Area - The faces of the above areas will be used to perform erosion and slope stability tests on the processed shale material at different slope angles.

5. Compaction Test Area - The central portion of the Phase I area will be used to carry out demonstrations of the compaction of the processed shale. The material will be placed and compacted in horizontal lifts and the mechanical and leachate behavior of compacted processed shale will be studied.

6. Slurry Testing and Demonstration - Concurrent with the compaction demonstration, a small slurry deposition test will be performed in a special facility to the west of the main Phase I disposal area. This will involve different slurry densities and will be subject to leachate, strength and revegetation research when it is finished.

7. Completion of Phase I Facility - After this sequence is complete, stacking of processed shale will continue in the Phase I containment area until it is filled. A corrugated metal pipe will be placed around the leachate sump areas and extended to surface to maintain access to the leachate collector system after dumping is complete.

8. Phase II - The Phase II system design will be based on the results of Phase I work. In general, it is not anticipated that any Phase II experimental work will be carried out except any follow-up work suggested by the results of Phase I.

2.4 SITE PREPARATION AND DIKE CONSTRUCTION

A. On Site Topography and Foundation Conditions - Four small, unbranched tributary streams, flowing in a northeastern direction, cross the RBOSC off-tract property. These streams are normally dry except for storm events or during the snow melt season. The valley areas are covered by bushes and the ridge areas are covered by trees. Average land slope is about 5% with ground elevations ranging from 7,110 feet, north of the Lurgi plant, to 6,850 feet northeast of the RBOSC off-tract land boundaries.

The results of field investigation during early November, 1980 indicate that the area is covered by 0.5 to 3.0 feet of topsoil. Underneath the topsoil is 3 to 15 feet of weathered sandstone which also contains some sandy silt. In the stream valley area, a maximum 18 feet of colluvial silty clay lies between the topsoil and the weathered sandstone.

B. Site Preparation - Prior to dike construction, topsoil will be stripped and stockpiled for reclamation use. For Phase I, the disturbed area is

approximately 75 acres, including dike embankment and pond areas but excluding access roads and stockpile areas. Based on the recent field investigation, the total volume of topsoil to be stripped is about 131,500 bcy, which will be stored in segregated piles located on north and southeast sides of the RBOSC off-tract property (Figure 5-2-9). Each pile is about 20 feet high with 4 to 1 side slopes and covers approximately 10 acres of surface area. This topsoil will be spread over the exterior slope of the dike embankment for reclamation once the Phase I dike embankment is completed.

The dike slopes will be tracked with a caterpillar tractor (up and down slope) after topsoil is applied. To reduce potential for development of erosion channels, runoff from the top of the dike areas will be directed by roadside gutters and drains to the collection ditch at the toe of the embankment. The rest of the topsoil will be used for revegetation demonstration programs during the processed shale disposal operation, and will eventually cover the final processed shale surface.

The bottom of the Phase I containment area will be graded and the leachate collection system will be constructed in such a way as to best incorporate the test program which is presented in Chapter 4 of this Section.

For the Phase II operation, the total additional disturbed area is 85 acres, and approximately 162,200 bcy of additional topsoil will be stripped and stockpiled at the same locations as for Phase I. Details of grading prior to embankment construction will be determined during Phase I. Utilization of this topsoil is the same as for the Phase I operation.

C. Dike Construction - The design layout of the dike is presented in Figure 5-2-9. The maximum dike crest would be at about elevation 7,110 feet, adjacent to the Lurgi process area. The final grade of the Phase I processed shale surface is designed to be 1.7% dipping from west to east. The final grade for Phase II is approximately 8.0% dipping in a northeast direction then 5.5% eastward.

The dikes will be constructed with overburden, end dumped by trucks and spread by bulldozers. During construction a water truck will spray water to

control fugitive dust. Total embankment material to be used for the Phase I containment area is estimated to be about 2.9 million bcy with processed shale estimated disposal capacity of 1.37 million cubic yards. Estimated output of processed shale during Phase I is 1.2 million tons. Based on processed shale properties discussed in Part 2.2 it is estimated that the average in-place density of the processed shale will be 65 pounds per cubic foot.

The available 3.8 million bcy of overburden from the Phase I operation is more than can conveniently be used for the Phase I containment area. The excess overburden will be used to construct part of the Phase II dike. The Phase II dike embankment volume is estimated to require approximately 3.3 million bcy of overburden material. This is available from the Phase II operation and the excess overburden left from Phase I dike construction. The processed shale storage capacity of the Phase II dike will be approximately 2.0 million cubic yards. The processed shale output from Phase II operation is estimated to be 2.0 million cubic yards (equivalent to 1.8 million tons). The relevant quantities for overburden, processed shale, dike volume, and capacity for the two phases are summarized in Table 5-2-1.

Table 5-2-1

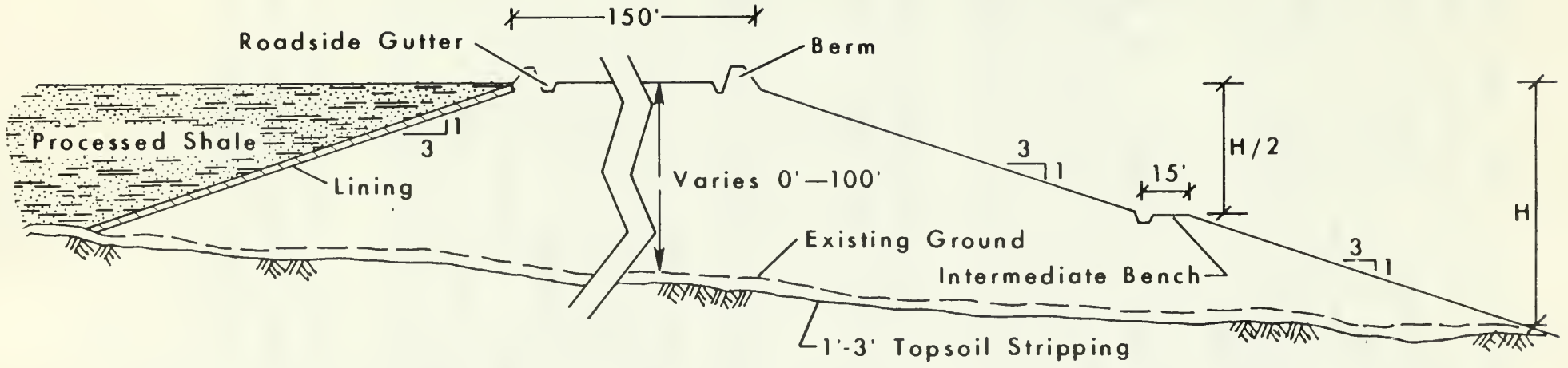
QUANTITY OF OVERBURDEN, PROCESSED SHALE AND DIKE EMBANKMENT VOLUME

	Phase I	Phase II
Overburden available	4.0×10^6 bcy(1)	2.2×10^6 bcy
Processed shale waste	1.37×10^6 bcy(2)	2.05×10^6 bcy
Overburden needed for dike	2.9×10^6 bcy	3.3×10^6 bcy
Dike storage capacity	1.44×10^6 cy	2.06×10^6 cy

(1) represents bank cubic yards. A swell factor of 1.35 is used for calculating the volume of overburden needed for the dike.

(2) processed shale density of 65 pounds per cubic foot is used for weight-volume transformation.

A typical dike cross section is shown in Figure 5-2-10. The top widths of the dike will be 150 feet for free-standing perimeter dikes and 100 feet for



Not To Scale

Note: 1. The Intermediate Benches Should be Placed at 100' Intervals on the Exterior Slope.

2. Dike Crest Width Will be Reduced to Minimum of 100' if the Overburden Material Appears Not Adequate.

3. Temporary Access Road Will be Provided Around Toe of Dike and Confined by Collection Ditchd Ditches.

Figure 5-2-10
Typical Dike Cross Section

the dike between Phase I and Phase II. Side slopes will be dressed to a final slope of approximately 3:1 with dike heights ranging up to 100 feet depending on the existing topography. Intermediate benches will be constructed on the exterior slope for the purposes of access, runoff interception and erosion control. The process used to calculate distance between diversion structures on these slopes is presented in Section 7, Chapter 8.3. The top of the dike is designed as an off-highway haul road with berms and ditches on both sides of the road.

The interior surface of the Phase I containment area will be lined with a synthetic liner such as Hypalon or high density polyethylene to ensure that leachate from the demonstration areas is intercepted for analysis. Also, a ramp along the interior slope will be constructed from crest to bottom for testing and other necessary operations within the containment area.

The results of the leachate and seepage demonstration from the Phase I operation will be used as a basis for final design of the Phase II and for optimization of an operation.

2.5 PROCESSED SHALE CONDITIONING, TRANSPORT, AND PLACEMENT

Processed shale streams from the retorts will be cooled from approximately 1,400°F to about 500°F in a heat exchanger and from 500°F to 200°F in a specially designed cooler. About 17.5% (by weight) of water will then be added for dust control and development of desirable properties such as strength and low permeability. The water for the moisturizer will be provided from the high TDS Lurgi plant waste water or from ground water. The processed shale received from the moisturizer will then be delivered to the containment area by belt conveyor and fed to a belt stacker system.

A conceptual layout of the delivery system is shown in Figure 5-2-11. The system will be made up of three components, namely; feeder belt, secondary belt and stacker belt(s). The feeder and secondary belts will be covered

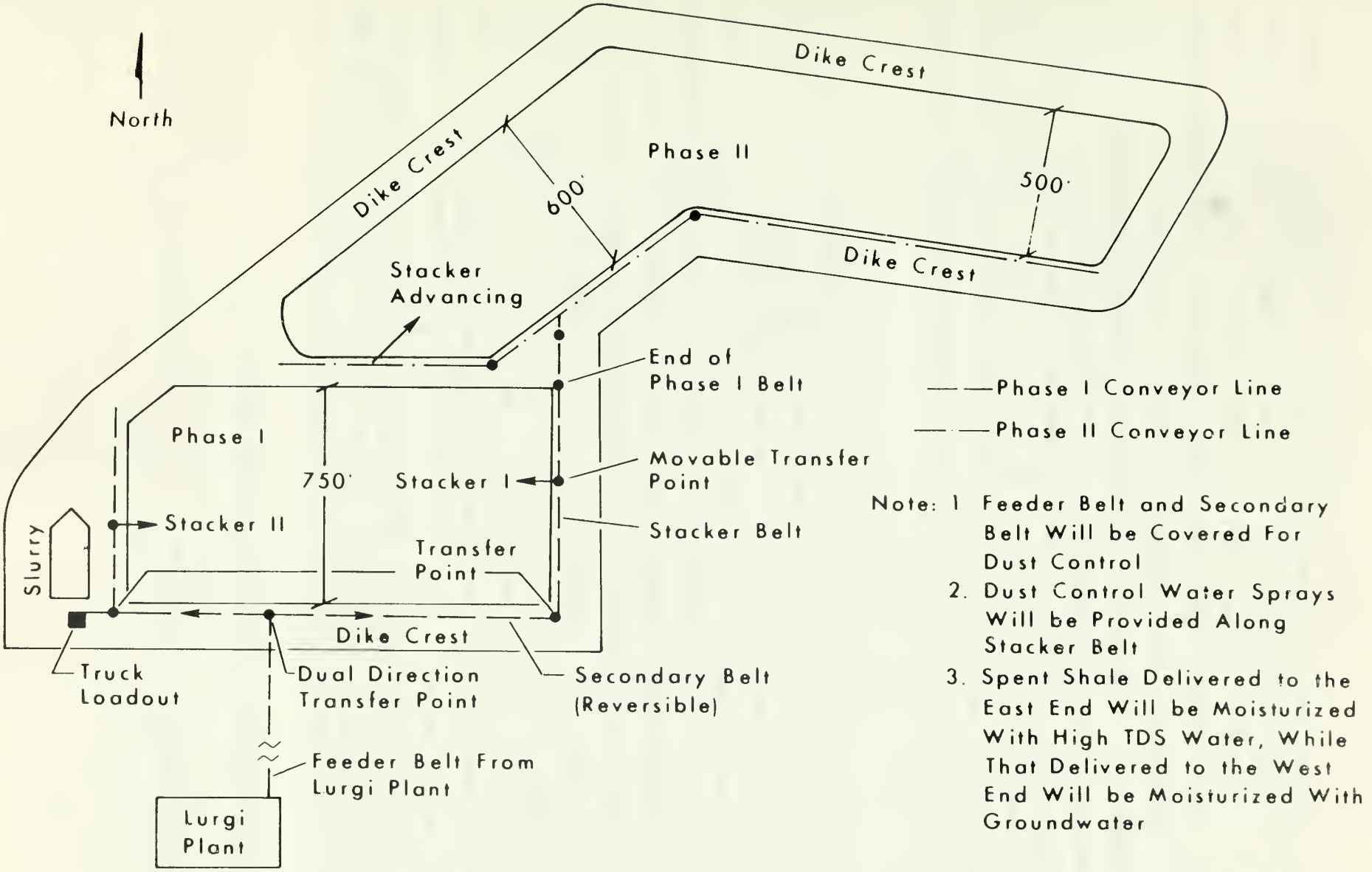


Figure 5-2-11
Conceptual Layout of Conveyor System

for dust control and winter maintenance protection. Provision for addition of water at transfer points will be made to compensate for evaporation losses, if required. Stackers will be readily available units. They will be provided with a movable tripper for stacking capability. The processed shale will be deliverable to the stacker on an articulated conveyor which can be constructed in 50 foot sections. Alternatively radial stackers could also be used and may offer some advantages. For the Phase I operation, the stackers could advance continuously from both the east end of the pond and the west as the processed shale is deposited to the desired elevation. Processed shale delivered to the east end will have been moisturized with high TDS water, while that delivered to the west end will have been moisturized with ground water.

The operation of the Phase I disposal system will be geared to a series of demonstrations related to potential problems with the disposal of the processed shale on a commercial scale. The details of these are discussed in Chapter 4, but in general, the stackers would advance from the ends until sufficient area has been provided for leaching and revegetation demonstrations. Simultaneously, processed shale will be delivered by truck to the central area where the material will be mechanically placed and compacted in lifts. As soon as the leachate test area is ready it will be flooded. Erosion studies will also be carried out on the slopes of the previously stacked material, together with tests on the specially constructed slopes. Following completion of the erosion and compaction demonstrations, the stacker would proceed to fill the balance of the containment area. During this period, a portion of the material would be slurried and pumped to a separate holding pond adjacent to the west end of the pit. Details of the Phase II operation would be based on experience gained from Phase I.

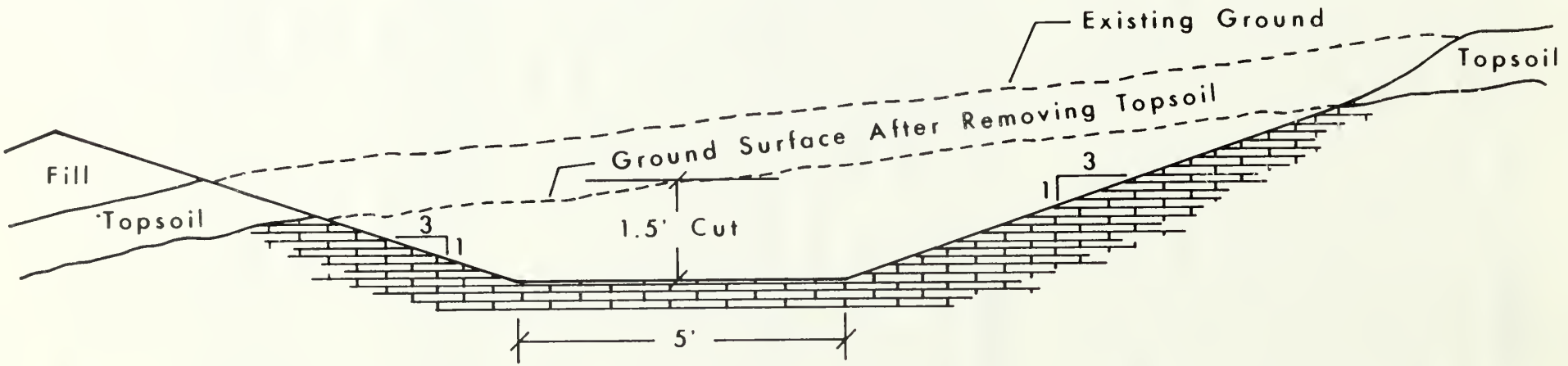
2.6 MAJOR EQUIPMENT, STRUCTURES, AND CIVIL WORK

A. Major Equipment - The equipment required for processed shale disposal is summarized by operational function as follows:

- Topsoil Stripping and Site Preparation
  - scrapers
  - dozers
  - graders
  - compactors
  - water trucks
- Dike Construction
  - front-end loaders
  - trucks
  - water trucks
  - dozers
  - scrapers
  - graders
  - specialized liner laying equipment
- Processed Shale Disposal
  - belt conveyor system
  - truck load-out hopper
  - graders
  - compactors
  - dozers
  - slurry equipment and pipe
- Demonstration Programs
  - pumps
  - irrigation system
  - instrumentation (Chapter 4)

B. Structures and Civil Works - Significant structures necessary for the processed shale disposal facility include dike embankment and water diversion facilities such as collection ditches and the sedimentation pond.

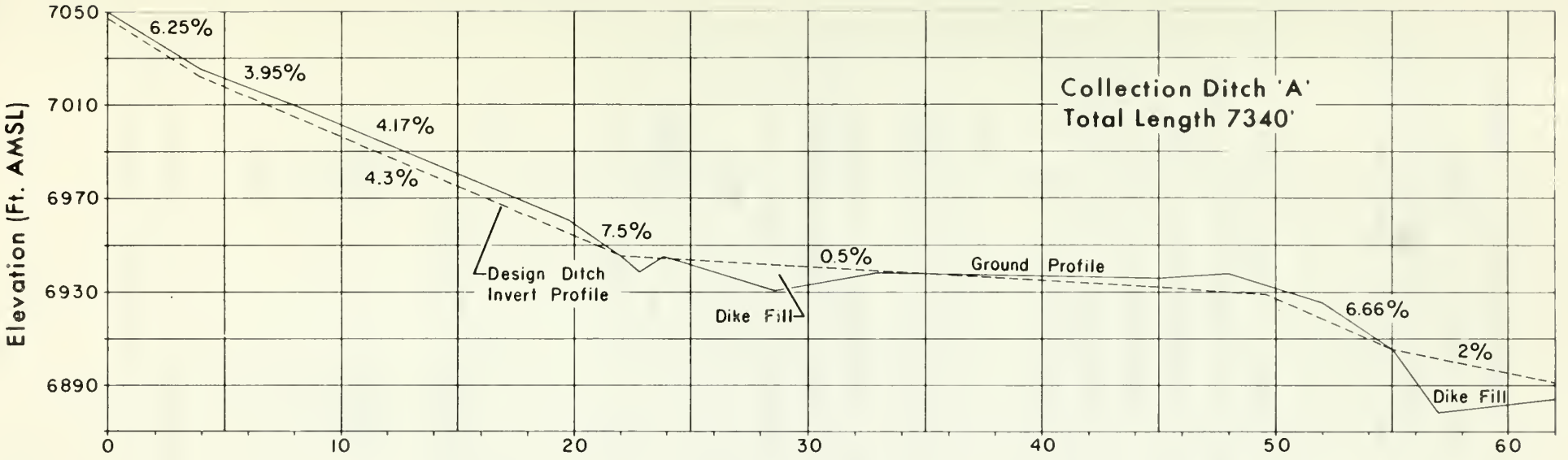
Ditches will be constructed around the processed shale containment area prior to construction to collect runoff from disturbed areas such as dikes, topsoil stockpiles, and covered processed shale fill as shown in Figure 5-2-9. This runoff, excluding runoff and leachate from the processed shale, will be conveyed into a sedimentation pond and then discharged into natural drainageways. A typical collection ditch cross-section is shown in Figure 5-2-12. Invert profiles for the ditches are shown in Figure 5-2-13.

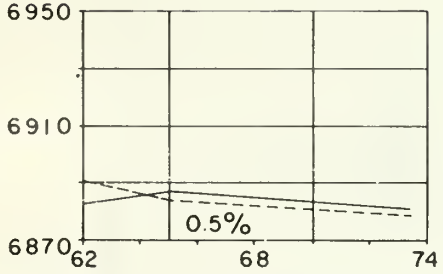


Note:

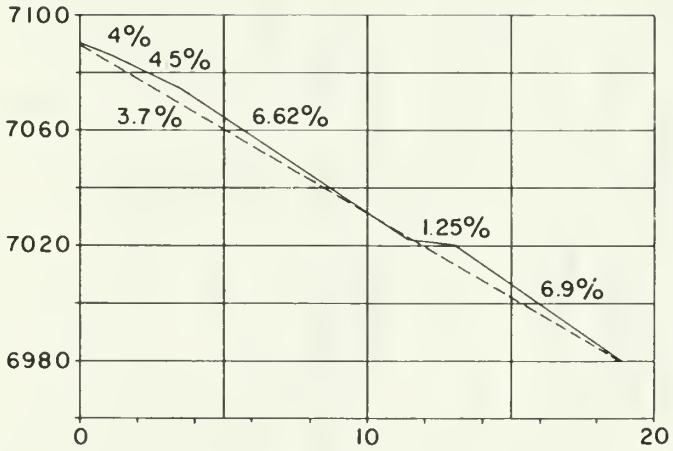
1. Minimum and Maximum Channel Gradients are 0.5% and 6.5%
2. Riprap Will be Provided on Steeper Slopes

Figure 5-2-12
Typical Collection Ditch Cross Section

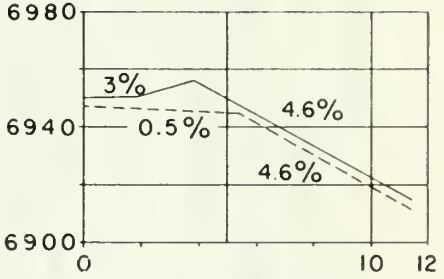




Collection Ditch 'A'
(Continued)



Collection Ditch 'B'
Total Length 1880'



Collection Ditch 'C'
Total Length 1140'

Figure 5-2-13
Collection Ditch Invert Profiles Processed Shale Disposal Area

The sedimentation pond will be completed with decant system and emergency spillway. The sedimentation pond will have approximately 6.0 acres surface area with maximum embankment height of about 35 feet and storage capacity of about 37 acre-feet at elevation 6,882 feet. Area/capacity curves are shown in Figure 5-2-14.

The maximum pond embankment cross section is shown in Figure 5-2-15. The embankment will be constructed after stripping of all vegetation and topsoil at the site. Material for the embankment will be derived from the haul road cut and, if necessary, from pit overburden. A downstream toe drain will be provided to control any seepage through the embankment. The embankment design and construction will comply with the regulations of the Colorado Division of Water Resources.

2.7 RECLAMATION

During Phase I, revegetation efforts will be directed toward reclamation of disturbed areas resulting from construction of dikes, ditches, sedimentation pond, and ancillary facilities. When the containment dikes are completed, topsoil will be placed on the exterior slopes and revegetation begun. Small areas of the processed shale disposal pile will be provided for reclamation demonstration during the Phase I operation. The acreage of disturbance for each phase of operation of the processed shale containment is listed in Table 5-2-2.

Table 5-2-2
ACREAGE OF DISTURBANCE DURING EACH PHASE OF OPERATION

	Phase I	Phase II	Total
Exterior dike slopes	49.5	48.5	98
Processed shale surface	25.5	36.5	62
Topsoil stockpile	20.7	0.	20.7

The type of vegetative cover will be in accordance with the regulations of Colorado Mined Land Reclamation (CMLR) and will be selected in consultation with the AOSO.

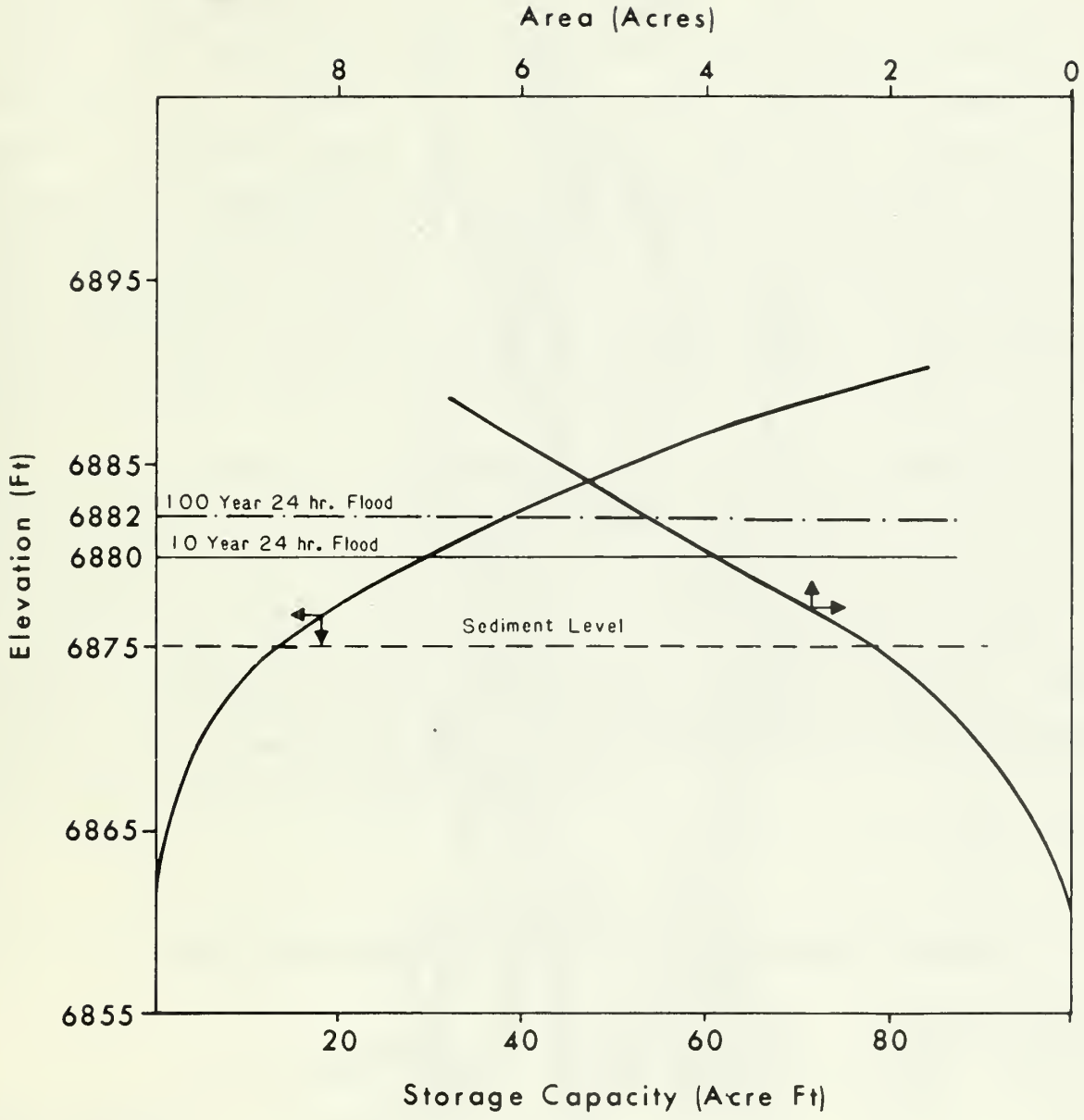


Figure 5-2-14
Sediment Pond Area/Capacity Curves

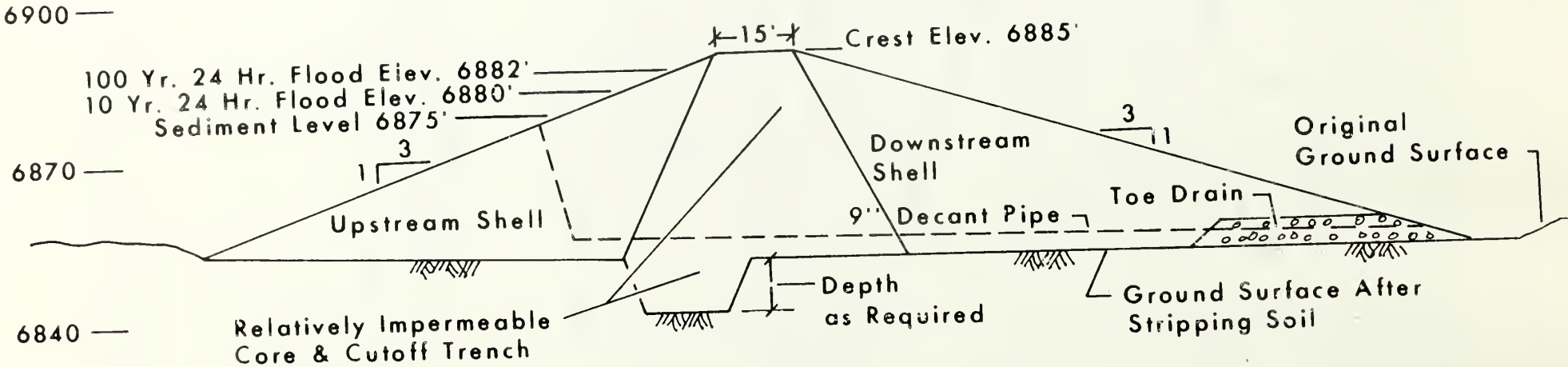


Figure 5-2-15
Maximum Section Sediment Pond

2.8 WATER MANAGEMENT PLAN

A. Water Requirements - The major water requirement for processed shale disposal operation will be for moisturization. Other water requirements include dust control during dike construction and processed shale disposal, revegetation and reclamation, testing program, and miscellaneous usage. Based on laboratory studies, it is considered that 15% to 20% water will be required for moisturization of the processed shale. Therefore, the water requirement for moisturization would be 147,600 gpd for the plant production rate of 3,500 tpd of processed shale at 17.5% moisture content. Water will be available from streams coming from the high TDS water at 49,280 gpd and the water supply system at 89,220 gpd assuming, 100% operating conditions.

Water for dust control is estimated to be 0.02 gallons-per-square-foot-per-day of disturbed area for the entire Phase I and Phase II operations. A 10,000 gallon water truck making 7-trips-per-day would be able to cover approximately 80 acres. The slurry water requirement is based on a 55% water content in the slurry. Also, the Phase I demonstration programs would require approximately 15 gpm (21,600 gpd) of water for 12 months. Miscellaneous water consumption of 5 gpm has also been assumed. Water requirements have been summarized in Table 5-2-3.

Table 5-2-3
WATER REQUIREMENT FOR PROCESSED SHALE DISPOSAL OPERATION

	Rates		Phase I		Phase II	
	(gpd)	(gpm)	Period (days)	Volume (acre-ft)	Period (days)	Volume (acre-ft)
Moisturization	147,600	130	300	136	450	204
Dust control	67,680	47	180	37	240	49
Testing program	21,600	15	365	24	0	0
Slurry water need	28,800	20	225	20	0	0
Miscellaneous	7,200	5	450	10	620	14
TOTAL	273,000	190		227		267

B. Surface Runoff Control - The control of surface runoff in and around the processed shale containment area will be required as follows:

- Surface water derived from the land adjacent to the disposal area
- Runoff from disturbed non-processed shale areas such as dikes and topsoil stockpiles
- Runoff from the processed shale pile

Surface runoff from the north part of the dike will be collected by Ditch A (Figure 5-2-9). Ditches B and C will collect runoff from the south part of the dike and natural drainage runoff. All this runoff will be conveyed to the sedimentation pond located on the east side of the RBOSC off-tract property for sediment removal and discharge. The design criteria for the ditch, sediment pond and embankment are as follows:

1. Collection ditches designed to pass 10-year, 24-hour peak discharge rate.

2. Sediment pond storage capacity designed to store the runoff volume of the 10-year, 24-hour storm and sediment inflow volume of 0.1 acre-feet per disturbed acre.

3. Sediment pond spillway design based on the 100-year, 24-hour storm.

4. Design rainfall values are 1.8 inches and 2.6 inches for 10-year and 100-year, 24-hour storm events, respectively.

During the processed shale disposal period, rainfall and runoff accumulated in the bottom of the containment area will be collected and evaporated in the pond which will be used for slurry tests near the completion of Phase I. Upon completion of Phase I and prior to reclamation, runoff from the processed shale surface will be collected at the east end of the Phase I surface in a 3-foot deep evaporation pond with one acre surface area. This pond should be sufficient in size to allow for evaporation.

The sedimentation pond discussed in Part 2.6 will have a drainage area of 246 acres. This area will generate 10.7 acre-feet of runoff for a 10-year

24-hour runoff volume and 3.6 AF/Y of sediment volume. The peak flow rate from the 100-year, 24-hour storm event for spillway design will be approximately 196 cfs. The sedimentation pond has capacity to store all the 10-year, 24-hour runoff and 3 years sediment volume plus some surcharge storage for the 100-year event. The sediment pond area capacity curves are shown in Figure 5-2-14.

C. Leachate and Seepage Control - Under normal rainfall conditions, it is not anticipated that there would be any seepage through the processed shale from the surface. In Phase I, however, as previously discussed, there will be sections of the area on which water will be kept ponded in order to induce an artificial seepage through the processed shale. This will afford the opportunity to establish the permeability of the material in-place, and the chemical quality of the leachate. Minor amounts of seepage may also be induced from irrigation demonstration plots and from the evaporation pond at the east end of the containment area. Even under artificial conditions, it may take months or even years for seepage to reach the bottom of the containment area. For example, assuming a permeability of 3×10^{-5} cm/sec, it is computed that it would take six months for seepage to extend to a depth of 50 feet under a constant head. As previously discussed, the containment area will be lined so that all seepage from whatever source can be collected and representative samples analyzed. Quantities of leachate are expected to be small. Any excess leachate accumulated during the demonstration period will be placed into an appropriate pond depending on water quality. Upon abandonment, the surface of the area will be regraded and revegetated to minimize the possibility of seepage through the processed shale.

No liner is planned in the Phase II processed shale disposal area for the following reasons:

- Moisture content of processed shale will be optimized so that no leaching will be induced.
- Yearly precipitation is not enough to provide leachate to any significant depth (annual evapotranspiration rate is at least three times the evaporation rate).

- No leachate will be produced because of ground water activity in the pile. RBOSC drilling has determined the ground water level to be 450 to 500 feet below the surface in the disposal area.
- No leachate testing will take place on the Phase II disposal area so a liner is not required to catch any induced leachate.
- Low strata permability will prevent leachate from reaching the ground water level for a very long period of time. Packer testing of the upper strata in the disposal area indicates a permeability of 10^{-5} cm/sec.

2.9 DUST CONTROL

Dust control methods anticipated in the dike construction and processed shale disposal operation include the following:

Dike Construction

- Water truck watering during the dike construction stage
- Topsoil cover and revegetation on the exterior dike slope, once the dike is completed
- Temporary revegetation on the topsoil stockpiles

Processed Shale Disposal

- Initial moisturization at plant
- Covers on the feeder conveyor belt (and secondary belt)
- Provision for additional moisturization at transfer points
- Provision for additional moisturization at stacker face
- Topsoil cover and revegetation on demonstration areas

The dust levels will be monitored by high volume particulate samplers to ensure that the PSD limits are not exceeded during any of the experimentation or demonstration activities.

CHAPTER 3

OVERBURDEN DISPOSAL OPERATION

There is approximately 5.2 million bcy of overburden in the Phase I open pit and an additional 4.2 million bcy in the Phase II open pit. Of the Phase I overburden approximately one-half of the material is true overburden and the remainder is comprised of low-grade oil shale from the L-8 and R-8 zones. In Phase II the true overburden comprises approximately two-thirds of the material with the balance being low-grade oil shale.

The open pit will be excavated in 25-foot lifts to allow for total segregation of each zone. All of the low grade oil shale will be used on the construction of the processed shale containment dikes for potential recovery in a commercial operation.

Most of the overburden excavated during Phase I will be utilized for construction purposes. Following site preparation (clear, grub and remove topsoil) the initial 1.0 million bcy of material will be used to construct the haul road, mine facilities access road and mine facilities area. Concurrently, 0.5 million bcy will be excavated from a cut which is required for haul road construction. This material will be used to construct a portion of the Phase I processed shale disposal dike. An additional 0.7 million bcy will be disposed of adjacent to the haul road and will be utilized as a topsoil storage area. The remaining 3.5 million bcy from Phase I will be used for processed shale dike construction. The material required for the construction of the Phase I dike is about 2.9 million bcy and the Phase II dike is about 3.3 million bcy. With a total of 4.0 million bcy of material available for dike construction in Phase I of which 3.5 million bcy is overburden from the open pit and 0.5 million bcy is from the haul road cut, a third or 1.1 million bcy of the Phase II dike will be constructed during Phase I operations.

Due to the limited area available on the RBOSC off-tract property a portion of the overburden from Phase II will be disposed of on-tract. Phase II overburden will initially be disposed of in the gulch immediately east of the

open pit on the south side of Dry Fork. Prior to disposal, topsoil will be removed from the area. In Phase II a total of 4.2 million bcy of overburden will be excavated from the open pit. Of the total, 2.2 million bcy will be used to complete construction of the Phase II dikes and the remaining 2.0 million bcy will be disposed of in the gulch east of the open pit.

CHAPTER 4

PROCESSED SHALE DISPOSAL DEMONSTRATION PROGRAM

4.1 GENERAL

The intent of the demonstration program will be the large scale evaluation of some of the factors which are important for optimizing the operation of a commercial facility. From a consideration of mining, processing, and regulatory priorities, the following variables have emerged as both important and capable of elevation during the demonstration program:

- Leaching characteristics: A major concern in the disposal of the processed shale is its susceptability to leaching by percolating water and the quality of the water which might be produced by leaching. A significant portion of the demonstration disposal program will therefore be devoted to the investigation of this concern. An important aspect of the investigation will be to determine the effect of moisturization water quality on leaching characteristics and other properties. Separate areas of the disposal facility will accordingly be devoted to processed shale moisturized with ground water and with high TDS process water.
- Stability: The in place stability of the disposed shale is also of major concern. In this context, stability includes resistance to erosion by wind and surface water as well as resistance to mass instability. During the demonstration program, wind erosion will be monitored and investigations of surface water erosion will be performed on a variety of exposed slopes within the processed shale containment area. Although some direct observations of slope stability may be possible during the stacking process, it is concluded that this problem will have to be investigated indirectly by determining of appropriate properties through in situ testing and laboratory testing of undisturbed samples obtained from the deposited processed shale.
- Revegetation: A critical variable in processed shale disposal is the revegetation of the surface of the pile. The program designates test

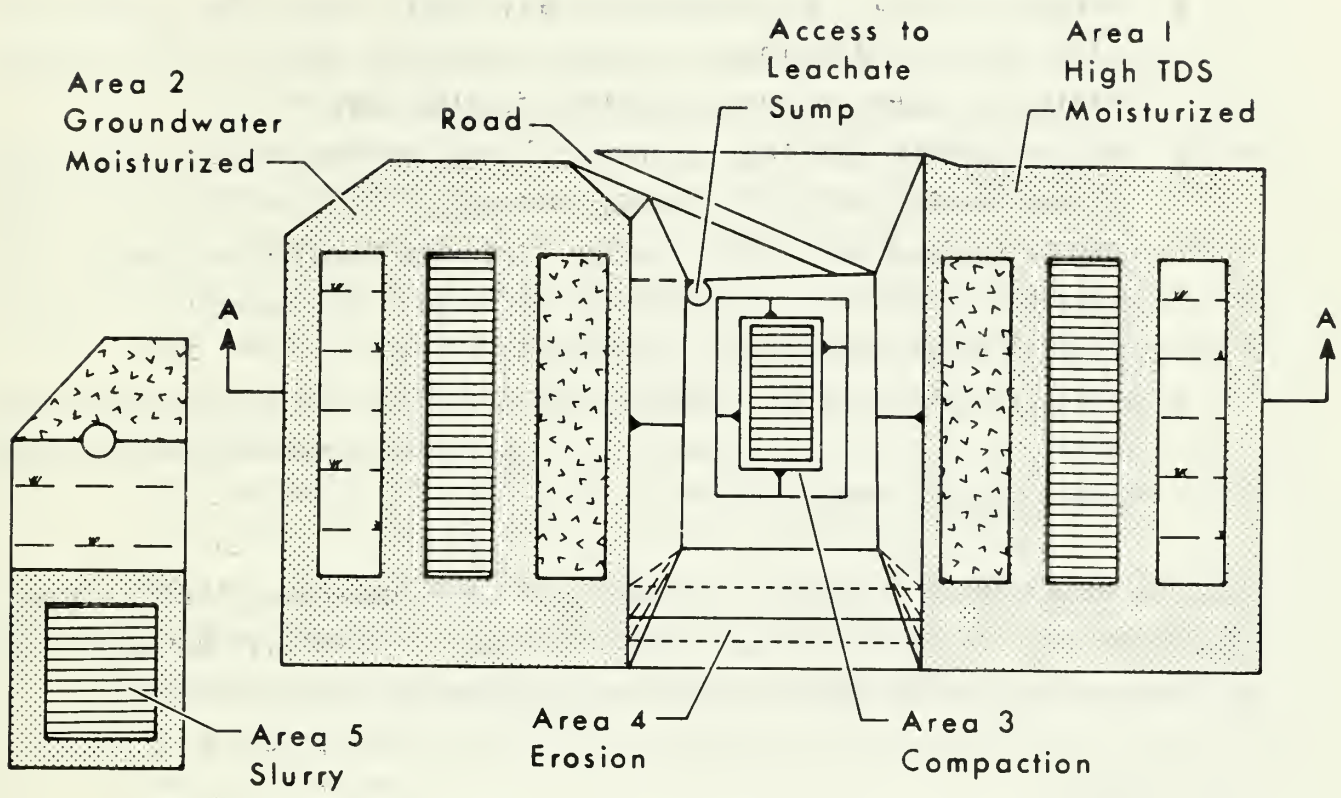
areas for revegetation available early in the life of the project in order to maximize the growing time on test plots. Additional areas become available as the project progresses.

- Materials handling: A belt stacking system was selected for deposition of the processed shale. This choice, in part, was made because of the systems suitability for the demonstration program and in part because conveyors are a likely candidate for use in the commercial operation. Systematic observations of performance will be made during the course of the program for application to the design of future systems. Trafficability of equipment on the processed shale pile surface will be an important aspect of the demonstration operation.
- Compaction characteristics: Density of processed shale affects its permeability, strength and volume. Various methods of compaction can be used to vary density. Therefore, an area of the processed shale disposal facility has been set aside to determine the compaction characteristics of the material and the resultant properties of the compacted processed shale.
- Slurry deposition: The characteristics of the processed shale make it attractive to consider transport and deposition in slurry form. Although the inherent disadvantages of this method make it unlikely that it could be used extensively at a commercial scale, a small containment area has been set aside outside the main facility to investigate the properties of slurry-deposited material.

The approach used in the design of the demonstration program has been to develop a relatively few test areas of reasonable size in order to keep the testing or demonstration of the above variables as simple as possible. Direct evaluation of prototype systems has been proposed wherever possible. In keeping with current regulatory trends, test instrumentation will be simple and is designed to produce unambiguous results.

A total of five specific test areas have been defined for the program. These are shown in Figure 5-4-1 and are described briefly below.

- Area 1: This area will be filled with processed shale moisturized with high TDS process water. It will be end-dumped in a single lift using a belt stacker unit.



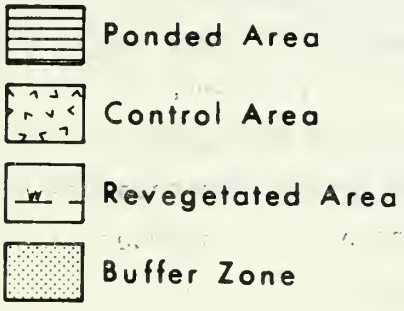


Figure 5-4-1
Layout of Test Areas for Phase 1

- Area 2: This area is similar to Area 1, except that it will be made up of stacker-dumped processed shale which has been moisturized using ground water.
- Area 3: This is the compaction test area. The compacted material will not fill the area, and when testing is complete this will be filled to capacity with end-dumped processed shale.
- Area 4: This area has been set aside for erosion testing. The slopes chosen are 1.25:1 (angle of repose), 2:1, 3:1 and 4.1. These latter slopes will be created using earthmoving equipment, and erosion tests will be performed on them. This area will also be backfilled after testing is complete.
- Area 5: This area has been set aside for testing of processed shale slurry. It is entirely separate from the main moisturized processed shale disposal area.

When the facility is complete, all test areas will have been filled to grade, revegetated in various ways, and fully reclaimed. There will be very little surface evidence of the wide variety of tests which have been performed.

4.2 LEACHING

A. General - Four leaching test areas will be used in the Phase I test facility. These will evaluate the gross permeability and leachate quality derived from:

- Stacked processed shale moisturized with high TDS water (Area 1)
  Stacked processed shale moisturized with ground water (Area 2)
- Compacted processed shale (Area 3)
- Slurry transported processed shale (Area 5)

Each active leachate test area will comprise the following elements:

- Pond
- Instrumented processed shale
- Leachate collector system

In addition to an active ponded area, each test will have a corresponding control area which will be identical except that no artificially supplied

water will be ponded on the surface. Instead, natural precipitation will be allowed to pond and infiltrate to simulate actual commercial conditions.

B. Ponds - The ponds will be uniform depth and will be kept full at all times. They will be supplied with water of constant quality, and water will be recirculated to the plant through the pond in order to ensure that the quality of water within the pond is not modified by evaporation. Ground water will be used to fill the ponds, for the following reasons.

- The largest potential cause of environmental degradation due to leachate in a commercial facility would be ground water flow through mine backfill processed shale, rather than from infiltration of incident precipitation. Therefore, it is desirable to model this condition.
- The quality of the pond water is easiest to maintain using the ground water which is subsequently consumed in the plant system.
- The use of collected rain water as a leaching medium would probably produce leachate of better quality than would be obtained using ground water. Because this would be unconservative in the sense that the worst result might not be produced, it was considered prudent to use ground water.

Ponds will be recessed into the processed shale pile, and will be a minimum one foot deep, except for the compacted processed shale pond, which will be ten feet deep. An allowance of one foot of freeboard will be made. To avoid any potential instability of the shale pile, ponds will be filled only after the shale pile crest has extended more than 100 feet from the crest center line of the pond. This restriction can be relaxed in the case of the compacted shale pile. Finally, the pond will extend only over full depth material. The surface above the sloping sides of the containment dikes will be left without pond cover in order to avoid "short circuiting" the system.

C. Instrumentation - Instrumentation in the processed shale is designed to monitor the movement of the wetting front through the pile, and the physical and chemical changes in the leachate and the shale which may occur during the leaching process. Three types of instrumentation are presently envisaged,

although other forms of monitoring may be used as well.

- Piezometers: A vertical series of piezometers will be installed to measure any head build-up in the shale material.
- Lysimeters: A vertical series of lysimeters will be installed to collect leachate samples from intermediate positions in the pile, and to positively identify the passage of the wetting front.
- Neutron Test Holes: The presence or absence of saturation can be detected by measuring the neutron absorption and reflection capability of the medium. As a test of this technology, repeated neutron surveys will be taken in cased holes located in the processed shale to identify the progress of the wetting front.
- Precipitation gauges
- Quantity of water ponded will be recorded
- Evaporation loss from ponds will be recorded

The location of all measuring equipment will be decided after consultation with the AOSO.

In addition to this nondestructive testing it is proposed to periodically drill test holes in the processed shale pond areas to obtain core of the processed shale material. Among other things, the degree of saturation and chemical variables will be tested at various depths. Holes will be backfilled so as to prevent them from becoming conduits for accelerated leaching.

D. Leachate Collector System - In order to ensure that the maximum amount of leachate is available for testing, and that an accurate measurement of leachate flow is made, all of the leachate which exits the base of the pile will be collected. In order to do this, the demonstration facility will be entirely lined with an impervious membrane liner, and the lined pond will be segmented by bunds (embankments used to control the flow of water) and individual collector pipes. In this way, leachate from each demonstration area can be individually collected and monitored.

The leachate collection system operates entirely under gravity flow. Leachate is collected from the various segmented areas by slotted PVC pipe which is placed immediately upstream of low bunds on the floor of the facility. Details of these bunds and of the pipe locations are shown in

Figure 5-4-2. The impervious liner is laid over the bunded material. The slotted collector pipe is laid on top of the liner, and a layer of filter sand is then placed over both. The sand serves as both a filter and as a conduit for gravity leachate flow to the collector pipe. Each leachate collector pipe is routed to the northern side of the facility floor, and then through the separating bunds west or east to a central collector sump. Here, individual leachate samples (if any occur) will be collected in separate containers. As the pile builds up, the sump will be protected by a large diameter corrugated metal pipe placed vertically, and built up with the pile. This will become a permanent access manway for the final facility, and will allow continuous sampling and inspection of the leachate collection system.

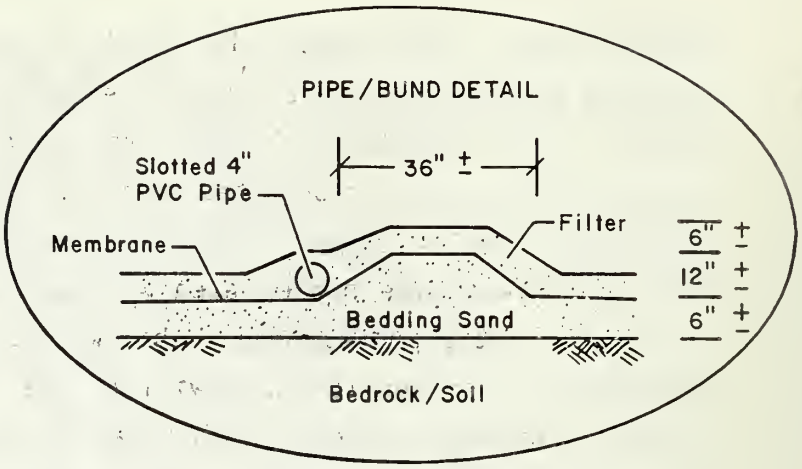
The total leachate flow will be periodically collected, measured, sampled, and tested at a certified laboratory for inorganic, organic, and toxic substances.

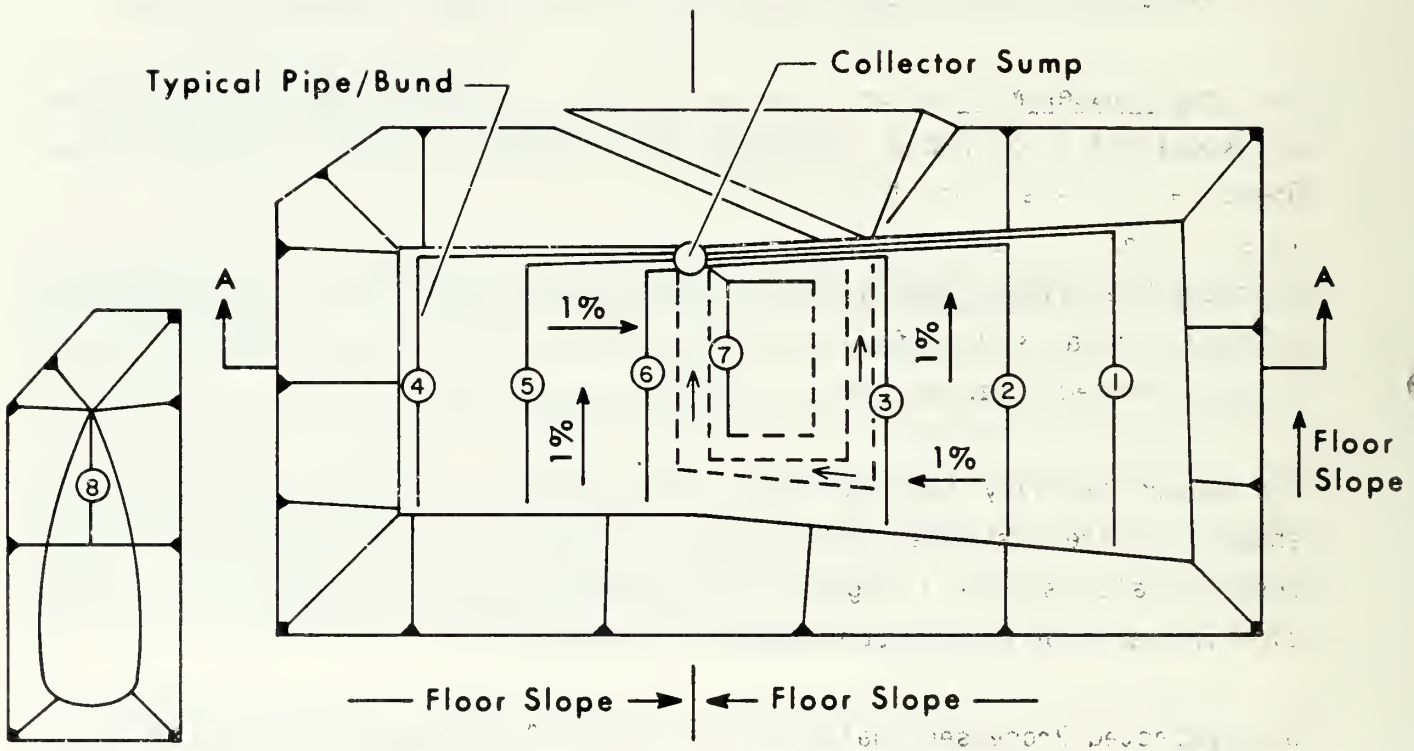
E. High TDS Moisturized Processed Shale Leachate Test - The test of stacked processed shale moisturized with high TDS water will take place in Area 1 (Figure 5-4-1) at the east end of the Phase I facility.

The water used for moisturizing in this case is essentially concentrated ground water and tertiary treated process water. It will be desirable to use water of this quality to moisturize processed shale in a commercial facility if it can be shown to be environmentally acceptable.

Stacking will progress to the west, producing a somewhat layered material with a dip of about 35° to 38° to the west. It is anticipated that leachate will percolate along coarser planes at this dip. Accordingly, the eastern collector system bund is located directly beneath the eastern leach pond embankment, but the western collector bund is located down dip at 35° to the west of the center line of the western leach pond embankment.

The instrumentation for this pond is planned for a location just inside the western embankment of the pond. This will allow intersection of the full section of the processed shale and even at the base of the pile the instrumentation will be within the material which "outcrops" in the pond area.





Pipe Legend

1 Revegetation - High TDS

2 Pond - High TDS

3 Control - High TDS

4 Revegetation - Groundwater

5 Pond - Groundwater

6 Control - Groundwater

7 Compaction (---- Indicates Bund Only)

→ Surface Runoff-Faces & Erosion Tests

8 Pond - Slurry

Figure 5-4-2
Layout of Pit Bottom & Leachate Collection System-Phase 1

This leachate test unit will be the first to go into service, as high TDS water will be available early in the processing. Thus, it is a critical test area, and may be the only area which produces any significant quantity of leachate within the Phase I test period.

Associated with the ponded area will be a control area, located 100 feet to the east of the ponded area. This will be identical to the ponded area with respect to construction, but will not be filled with water except by direct precipitation. Instrumentation and leachate collection will also be identical. This area will more realistically analog field leachate performance in a commercial facility.

F. Ground Water Moisturized Processed Shale Leachate Test - The test of stacked shale moisturized with ground water will take place in Area 2 (Figure 5-4-1) at the west end of the Phase I facility. This water would be used for moisturizing if it is demonstrated that high TDS water is environmentally unacceptable, or if no high TDS water is available. The testing of leachate from this area is therefore important, but not as important as from the high TDS moisturized area.

The entire facility is a mirror image of the high TDS moisturized processed shale test area, and is identical except that the average thickness of processed shale is somewhat greater (60 feet compared with 45 feet), and the time of operation will be somewhat less.

G. Compacted Processed Shale Leachate Area - Compaction of processed shale will decrease its permeability. In order to increase the potential for obtaining leachate through the compacted processed shale during the Lurgi demonstration project it is proposed to:

- Shorten the leachate path--to ten feet, which is between four and six times shorter than in the stacked shale tests
- Raise the driving head--by deepening the pond to ten feet, which gives approximately twice the gradient that will exist in the stacked shale tests.

The result of these two changes is to reduce the time for percolation by a factor of between 8 and 12, which will hopefully at least partly compensate for the reduced permeability of the medium.

Because of the space taken up by the embankments which impound the ten feet deep pond in this test there is no control area. The total compaction test area is about 1-1/2 acres, of which about half an acre is ponded. Instrumentation will be similar to that used in other leach tests, except that only a single piezometer and lysimeter will be used due to the small depth of processed shale.

After all other processed shale areas are completed, the volume above and beside the compacted shale area will be backfilled using the spreader system.

H. Slurry Transported Processed Shale Leachate Area - The slurry transported processed shale leachate test area (Area 5, Figure 5-4-1) will be a small scale analog of the "dry" disposal areas. It will contain a segmented leachate collection system, a ponded area and a control area. Instrumentation and leachate collection systems will be used in the main area.

4.3 ENGINEERING PROPERTIES

A. General - The behavior of large processed shale piles has not been extensively evaluated because of the lack of sufficient processed shale. The RBOSC facility offers the first major opportunity to evaluate the engineering behavior of processed shale at a scale approaching commercial. The tests presently envisaged include evaluation of:

- Erosion
- Compaction
- Slope stability
- Settlement

The approach to testing will in all cases, be to relate results to laboratory property tests of the material, so that scale-up of performance can be made should later process modifications occur which might invalidate the

demonstration scale tests as prototype. Primary variables which are expected to influence behavior and which will therefore be carefully monitored are:

- Grain size
- Pozzolanic activity
- Moisture content
- Quenching/moisturizing history
- In situ density
- Temperature history

The first two variables are largely fixed for a given process, while the last four variables can be modified to achieve a desired result within fairly wide ranges.

B. Erosion - Wind and water erosion will be evaluated by direct testing of slopes within the test area. The performance of dumped faces (angle of repose) will be tested at the edges of Test Area 1 and 2. In addition, processed shale slopes of 3:1 and 2:1 will be constructed on the south side of the facility using dumped and graded material, as shown in Figure 5-4-1.

Wind erosion will be evaluated by exposure over a long period to the prevailing winds. Particulate monitoring and physical measurements of material removal will provide complementary data on the influence of slope and aspect on erosion.

Water erosion testing will be undertaken by sprinkling the face of the pile with water at rates corresponding to major storms and sustained rainfall. Data obtained will be used to calibrate the universal soil loss equation for this material. This data will be of considerable use in planning sediment removal and handling systems in a commercial facility. Gullying or channeling will also be studied by directing sustained localized flow down the slopes. All water which runs off the slope during these tests will be captured, measured, and sampled for quality. This data will allow calibration of a runoff equation for commercial facilities, and evaluation of runoff quality which will be important in a commercial operation.

C. Compaction - In order to determine the physical properties of processed shale in the context of a commercial operation RBOSC will simulate those properties in this demonstration program. An important variable which affects the strength, permeability and volume of processed shale in the laboratory is its density. To simulate the density of the processed shale in the large backfills contemplated in a commercial operation various methods of compaction will be tested. Specific compaction evaluations planned for the demonstration program are:

- Self Compaction: The pile will have processed shale depths from 0 to 60 feet which will be loose dumped from a stacker. It is proposed to directly measure densities achieved by self compaction and extrapolate these results to the higher commercial processed shale piles.
- Impact Compaction: A common method of increasing compaction using a stacker is to increase the drop height and hence increase the dynamic compaction effect. If space allows, it is planned to test this effect by varying drop height (dust generation will also be simultaneously measured - see below).
- Mechanical Compaction: A number of mechanical compaction methods will be tested in the construction of the compaction leachate test area, including vibratory, sheepsfoot, and smooth rollers, rubber tired vehicles, and tracked vehicles.

Results in each case will be assessed against standard laboratory and field compaction tests to allow calibration and scale-up.

D. Slope Stability - As the highest slope to be constructed in Phase I of the study will be only 60 feet, the likelihood of obtaining useful direct slope stability information for commercial sized slopes is remote. Therefore, the method of investigation for slope design parameters will be to take undisturbed samples of processed shale from coreholes in the full range of material placed in the facility. These samples will then be tested to produce the necessary design strength parameters.

In addition, if feasible, in-place testing of the processed shale will be carried out using such devices as cone penetrometers and pressure meters. By

carrying out this work at intervals throughout the demonstration program, the gain or loss of strength with time will be evaluated.

E. Settlement - The ability to predict settlement which will result from full scale processed shale piles is important because of the impact that settlement can have on final landforms and drainage patterns. It is also of importance if structures are to be placed on the processed shale.

The field observation of settlement will be performed using surface survey hubs and settlement plates located at various depths in the processed shale, as shown schematically in Figure 5-4-3. To complement the results from a number of such installations, core samples will be subjected to consolidation testing in the laboratory. The comparison between predicted and measured settlement may allow a calibration of the laboratory results which will aid in future design. An attempt will be made to measure changes in settlement behavior as the material ages.

4.4 OPERATIONAL BEHAVIOR

The demonstration operation gives an excellent opportunity to evaluate the operational behavior of the processed shale with respect to handling, trafficability, dust control and revegetation.

A. Materials Handling - The requirements of the demonstration project to handle the processed shale provide an opportunity to evaluate the materials handling problems associated with processed shale. The following transport systems will be used and their effectiveness assessed.

- Conveyor/Stacker: This is the primary method of transport presently proposed for the processed shale facility. An enclosed conveyor system leading to two small stackers is planned. All aspects of the system performance will be monitored including belt life, material build up, system reliability, dust generation, fire prevention and processed shale watering.

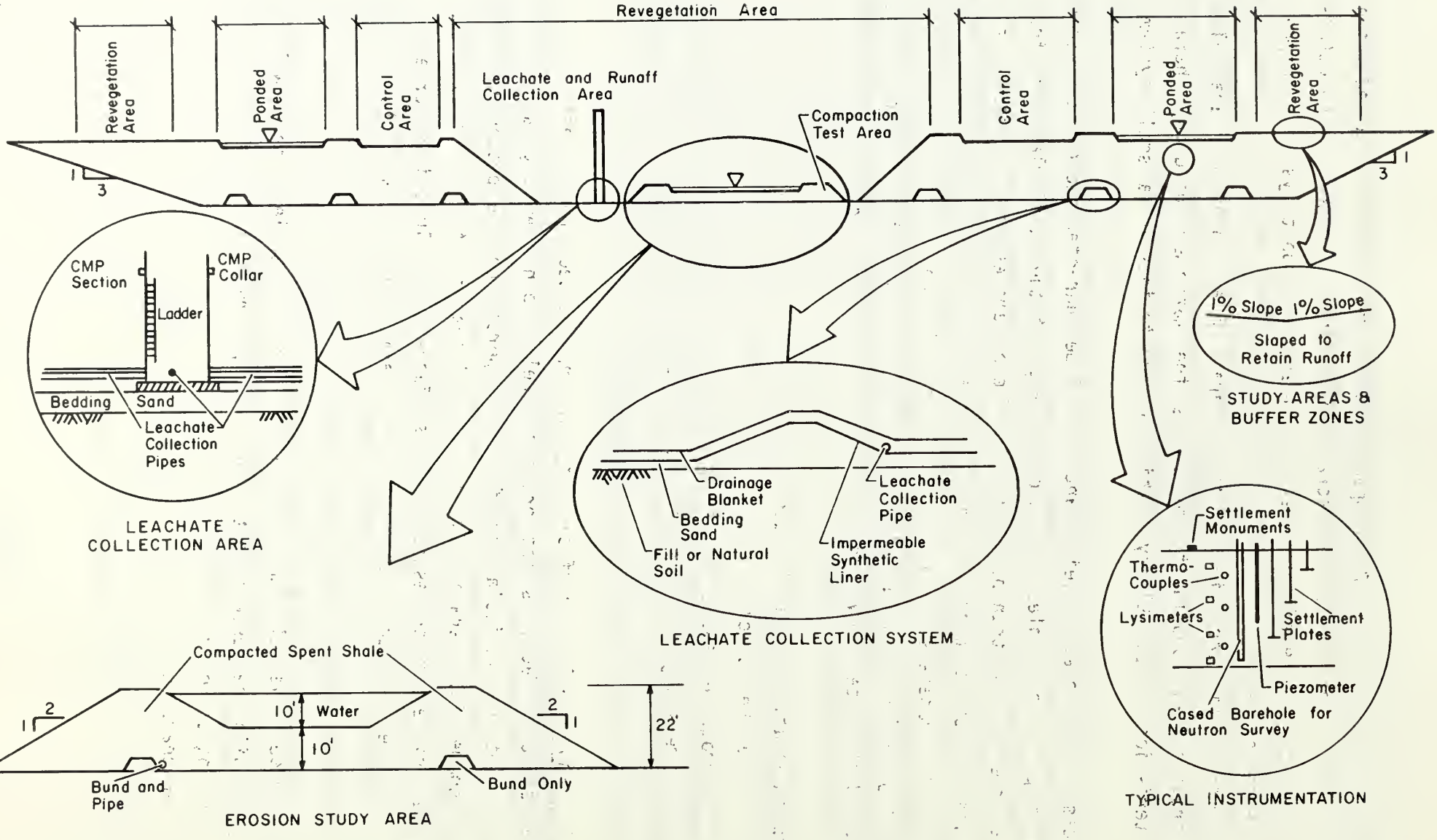


Figure 5-4-3
Sections Through Phase I Demonstration Shale Pile

- Truck and Scraper: The compaction test area will be installed using truck haulage and possibly scraper placement. This will allow determination of the effectiveness of wheeled transport systems for processed shale.
- Slurry: The inclusion in the program of a slurry test area also provides an opportunity to assess the materials handling characteristics of the slurry within the constraints of a small system.

In all cases, the material being handled will be characterized by laboratory testing of periodic samples from the discharge of the Lurgi plant and from the discharge of the transport system. These samples will be tested for grain size, moisture content, pozzolanic activity, temperature and some mineralogical parameters. This will allow correlation between material type and handling performance. In addition, the output rate of the plant will be measured and the total flow accounted for in the disposal area.

Some experimentation is anticipated particularly with respect to moisture content. While the scarcity of available water suggests that moisture content of the processed shale should be kept low, the materials handling constraints require a high moisture content. This variable will be studied with care.

B. Trafficability - The trafficability of unprotected and protected Lurgi processed shale surfaces is not presently well known. As a great deal of heavy equipment and vehicular traffic will operate on the processed shale pile in a commercial operation it is essential that the feasibility of movement across different processed shale surfaces is evaluated in order to include required surface modification or armoring in commercial scale designs.

The performance of vehicles and equipment on processed shale surfaces will be investigated with the respect to the following parameters:

- Bearing capacity
- Wear characteristics

- Dust generation
- Performance during precipitation
- Freeze-thaw performance

Four classes of processed shale surface will be investigated during the program:

- Loose dumped: This is the processed shale placed by the stacker without any surface preparation. Clearly, trafficability on this material is critical for stacker design, and for conveyor moving equipment. However, if it could be shown that trafficability was not a major problem on this loose material, then substantial savings could be realized in a commercial operation.
- Compacted: Compacted processed shale should behave better as a traffic surface than loose dumped. The compaction test area will be used for vehicle tests and for standard field and laboratory bearing and performance tests. Different compaction methods and compactive efforts will be tested.
- Slurry Deposited: Processed shale slurry conditions represent a special case of potential trafficability problems. Data is needed on the time and treatment necessary before vehicles can move across a completed pond area. Tests will be carried out on the slurry disposal area and will be conducted on a "design-as-you-go" basis.
- Paved/Armored: The approach to testing road design for processed shale will be to perform the standard tests on the material and to design a series of road segments. These segments will then be built and traffic tested with design equipment loadings.

These tests should allow design of haul roads, equipment and off-road access on processed shale piles for a full scale facility.

C. Dust Generation and Control: The generation of dust from shale disposal activities will be investigated. Detailed research of dust generation and control will be concentrated in three areas:

- Wind Generated Dust: The influence of slope angle, aspect, and processed shale properties on wind generated dust will be investigated in the facility. The two main faces of the dump face east and west, and the prevailing wind is from the southwest. Thus, a wide range of combinations of wind direction and slope aspect should be possible.
- Materials Handling Dust: The major potential dust generator is the processed shale handling system. As noted above, several systems will be tested during the demonstration operations, and a range of experiments on dust generation and control will be performed. Monitoring of conveyor transfer points, stackers, sprays, bag houses, and other equipment will provide performance data which will allow commercial equipment design optimization for minimum dust emissions.
- Traffic Generated Dust: The dust generated by traffic depends on a range of variables including pavement type, vehicle type, speed, and ambient conditions. During the pavement and trafficability tests, dust generation and mitigation studies will also be undertaken to provide input into future permitting of equipment and health studies.

Control and generation of dust are very much governed by processed shale moisture content. A significant use of water in a commercial sized mine will be for dust control. This segment of the demonstration program is designed to define the minimum amount of water needed to meet acceptable dust standards in a commercial operation.

D. Revegetation - In order to reclaim processed shale disposal sites, now and in the future, it is necessary to demonstrate positive schemes for maintaining a vegetative cover. In support of this, a number of revegetative studies are provided.

1. Experimental Greenhouse Studies

a. Objectives - These studies are designed to provide data on the reclamation protential of Lurgi processed shale. Greenhouse studies are beneficial in that they provide preliminary data in a timely manner, can be conducted with a relatively small volume of Lurgi processed shale which is presently available, provide a controlled environment within which leaching

and potential uptake studies can be conducted, and provide input to the design of more extensive field demonstration plots.

b. Methods - The experimental greenhouse studies are being conducted by Native Plants, Inc. of Salt Lake City, Utah, and include growth, trace elements uptake, and germination potential studies on, and over, Lurgi processed shale. These studies are scheduled to include a six-month period of growth and began during September 1980.

The five plant species being tested in these studies include pubescent wheatgrass, Indian ricegrass, Lewis flax, four-winged saltbush and rabbitbrush. These species will be grown as tubelings and transplanted into treatment plots so as to ensure pre-experimental uniform plant size and to minimize the growth period required. Growth and trace element uptake experiments are utilizing 25 plots per treatment, which represents five replicates for each species being considered.

Treatment combinations being considered for growth and trace elements uptake studies include 15 cm of processed shale covered by the following combinations of subsoil/overburden, topsoil and pea-size gravel:

- 15 cm topsoil
- 15 cm subsoil/overburden, 15 cm topsoil
- 30 cm subsoil/overburden, 15 cm topsoil
- 30 cm topsoil
- 15 cm subsoil/overburden, 30 cm topsoil
- 30 cm subsoil/overburden, 30 cm topsoil
- 15 cm pea-sized gravel, 15 cm topsoil
- 30 cm pea-sized gravel, 15 cm topsoil

The latter two of the above treatment combinations are being studied to determine if, or how well, the subsoil/overburden material (in the other treatment combinations) is functioning as a capillary barrier to the upward movement of dissolved substances from the processed shale.

Controls being used in the growth and trace elements uptake studies consist of 15 cm of processed shale, 15 cm of topsoil and 30 cm of topsoil. Topsoil and subsoil/overburden being used in the studies are from Tract C-a. The pea-sized gravel is from a totally unrelated site.

Monitoring is being conducted throughout the study to ensure that watering and lighting conditions are uniform for all treatment combinations. At four periods during the study, plants are being evaluated for vigor and growth. Data gathered during these periods includes plant height and leaf number and size. Photographic documentation of growth is also being compiled throughout the duration of the study.

After six months of growth, the root systems of the plants will be excavated to view and obtain data on the interaction of the roots with the processed shale. Five individuals of each species in each pot will then be pooled and ashed, and chemical analyses performed. Plant material will be analyzed for boron, molybdenum and fluoride. If soils analyses indicate that arsenic and selenium levels are high, plant materials also will be analyzed for these elements.

Studies of the germination potential of processed shale studies are being conducted using twelve species (50-100 seeds per species), and include five replications for three seeding depths and one control. Seeds are being sown on the surface of the processed shale, as well as at 1 and 2.5 cm depths. The control treatment consists of topsoil from Tract C-a with seeds sown at a 1 cm depth.

2. Field Demonstration Studies - A number of revegetation plots will be developed on the processed shale disposal area (Figure 5-4-4).

a. High TDS Moisturized Processed Shale (Area 1) - This vegetation plot becomes available early in the life of the facility to allow the maximum possible growing time. This kind of processed shale is the most likely for a commercial operation. The central vegetation plot will be likely over this type of material.

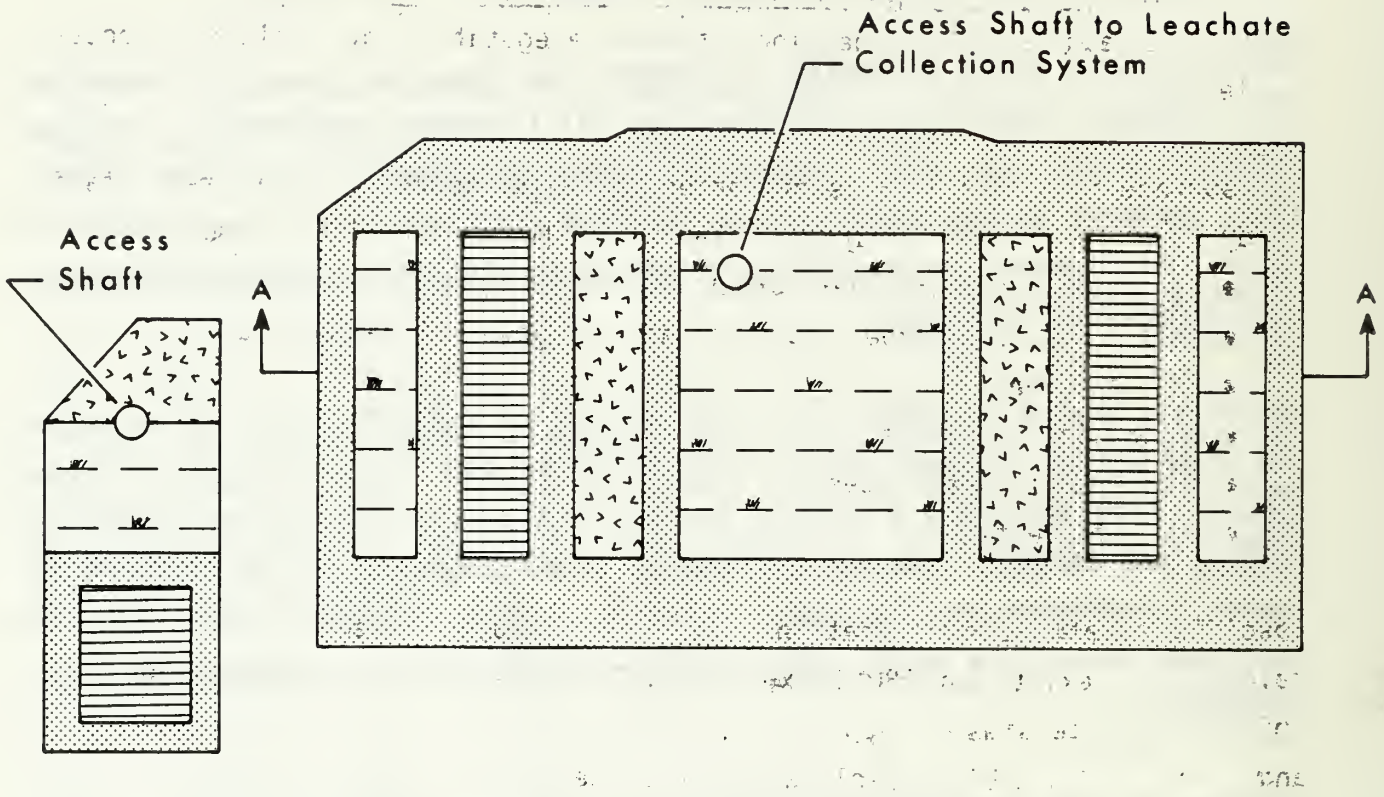


Figure 5-4-4
Layout of Test Area at End of Phase I Disposal

b. Ground Water Moisturized Processed Sale (Area 2) - This revegetation plot becomes available a little later than that in Area 1, and will be used to duplicate the plot on the high moisturized processed shale.

c. Slurry Transported Processed Shale (Area %) - This plot is designed to address the question of the revegetation over slurry processed shale.

The surface treatment of the processed shale is important to the revegetation study. Parameters which may be varied during the test period include:

- Thickness of capillary break
- Thickness and type of topsoil and/or topsoil-like material
- Plant type
- Fertilizer type and amount
- Irrigation practices (if any)
- Mulch treatments

Specific treatment combinations will be developed based on information obtained from existing RBOSC experimental revegetation plots, Colorado State University intensive study plots, and input from the Area Oil Shale Office and Colorado Mined Land Reclamation personnel.